METALLURGIA

The British Journal of Metals

(INCORPORATING THE METALLURGICAL ENGINEER.)

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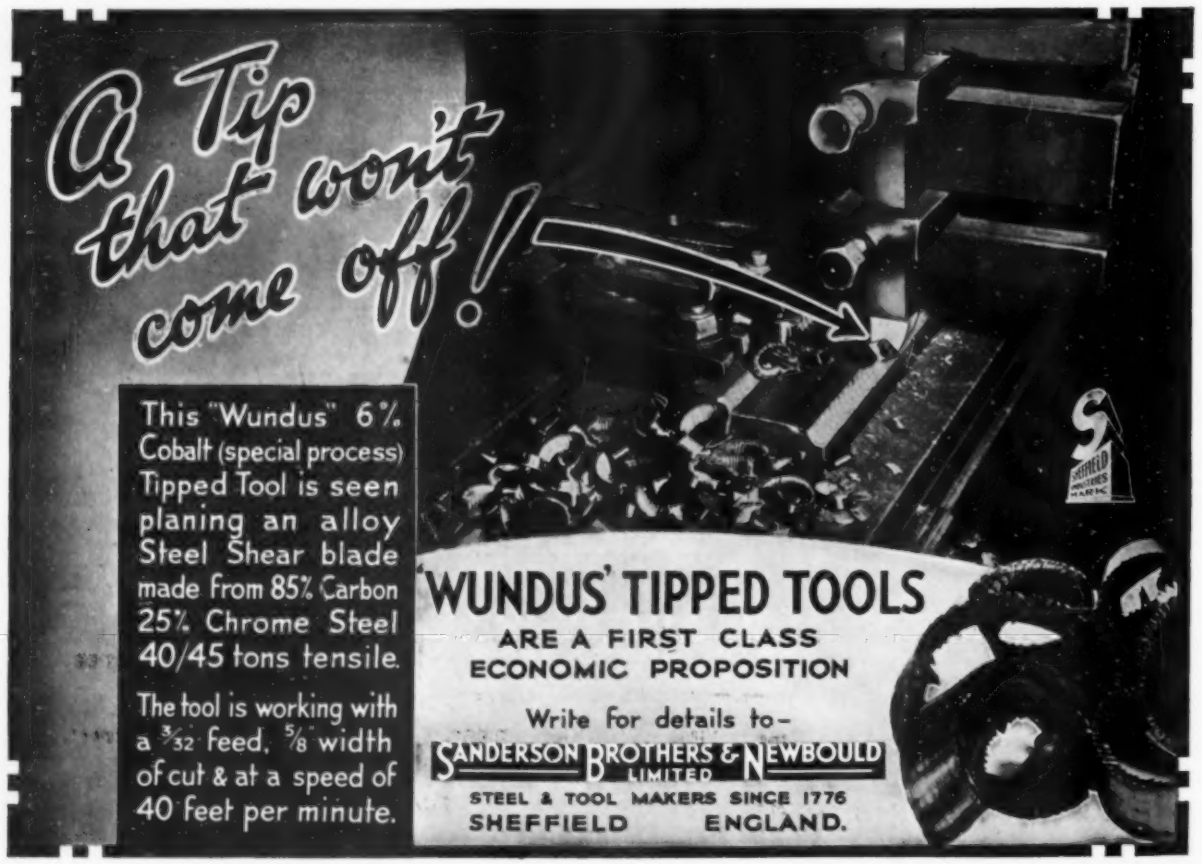
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METALLURGIA

THE BRITISH JOURNAL OF METALS.
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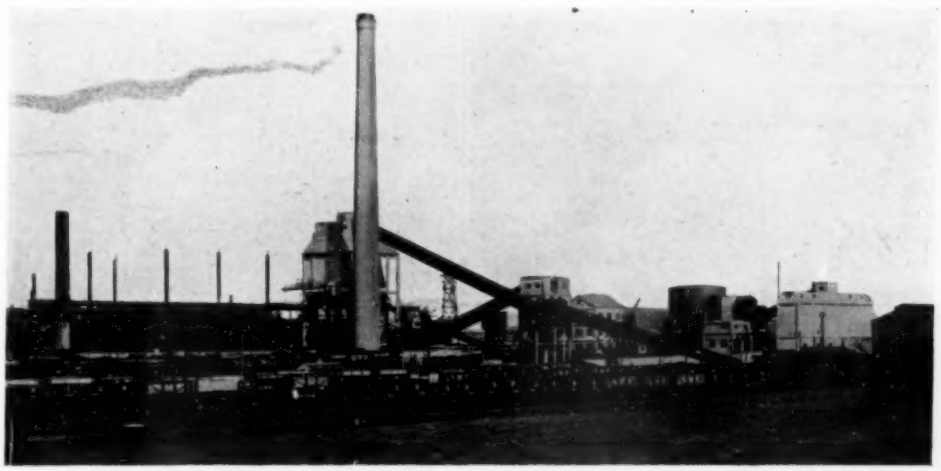
SEPTEMBER, 1936. VOL. XIV., No. 83.

Economy and Efficiency in Iron and Steel Manufacture

Installation of Coke Ovens and By-product Recovery Plant at the Works of the Workington Iron and Steel Co.

The trend of progress towards the manufacture of cheaper iron and steel in this country is given a further impetus by the installation of a modern by-product coking plant at the works of the Workington Iron and Steel Co.—an associated firm of the United Steel Companies, Ltd. This installation is the latest of the many developments made at these works during recent years, and represents an excellent example of the application of modern equipment and technique to meet post-war conditions.

BRITISH iron and steel manufacturers always have been associated with the best of the world's producers; with them quality manufacture has become a habit, and strenuous efforts continually are being made to maintain this enviable position. During the post-war years, however, intense economic competition necessitated greater production efficiency, and since quality remained an important objective, the industry was faced with many complex problems, the solution of which involved careful study with a view to reorganisation to ensure economy in manufacture. During recent years much time and money has been devoted to the re-establishment of the iron and steel industry, and in recent months new high levels of production have been attained. The remarkable improvement recently experienced in the industry is, however, largely due to the courage and foresight of many firms which embarked on costly reorganisation schemes at a time when trade was at its worst, and before the introduction of protective measures gave an impetus to development. Of these mention may be made of the United Steel Companies, Ltd., which has done much to restore confidence in the British iron and steel industry.



General view of plant, showing (from right to left) blending bunkers, gasholder, crusher-house, coal-transfer house, and coke-screening stations, ovens coal bunker, ovens stack and coke side of battery.

Post-war conditions led to the formation of the United Steel Companies' Cumberland Group, which brought within one organisation iron-ore mines, limestone quarries, coal mines, coke-ovens, blast-furnaces, and acid Bessemer steelworks. Apart from the elimination of redundant overhead costs, this combination opened opportunities for the improvement of processes at the various stages, with the object of reducing manufacturing costs. The successful continuance of iron and steel manufacture in Cumberland largely depends on the obtaining of pure low-phosphorus pig iron at a minimum cost. In the achievement of this, the main factors are the costs of blast-furnace operation and of blast-furnace raw materials.

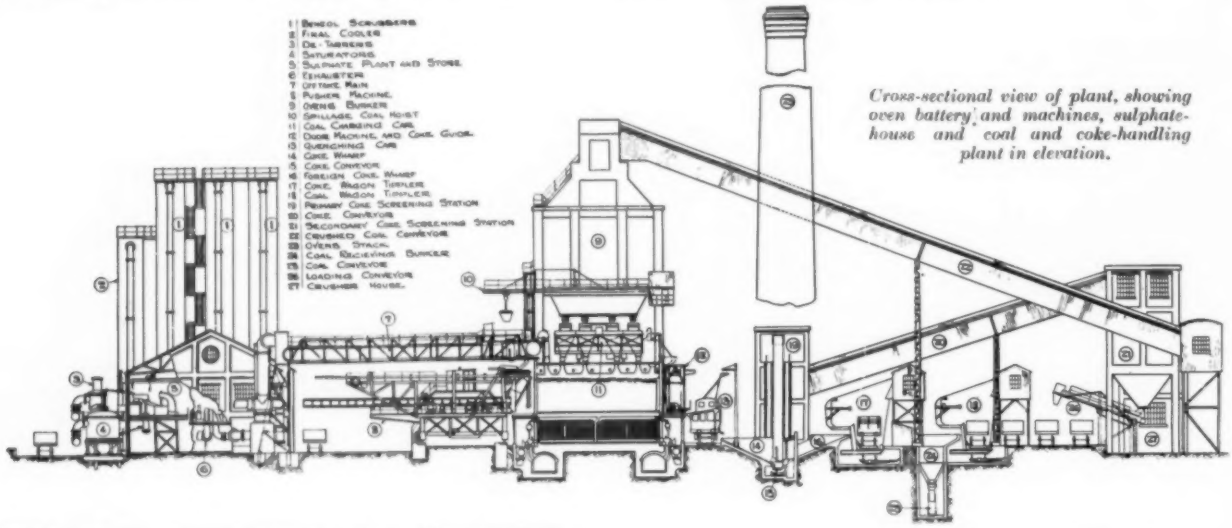
In pre-war years the eminence of the iron and steel industry in this country was built up on cheap fuel conditions, when no appreciable advantage could be gained by the expense involved on plants necessary to save fuel. Since the war, however, fuel efficiency has become a factor of major importance, not only in reducing the costs of blast-furnace operation, but in all operations in the manufacture of steel involving heat. The problems encountered in heat utilisation vary in different works, but progress in the design of coking recovery plants has led to the installation of several of these plants where their high efficiency can be used to advantage, and in pursuance of their policy of reorganisation the United Steel Companies, Ltd., decided to install a modern by-product coking plant which was put into operation recently.

The installation comprises 53 Becker ovens, designed and erected by the Woodall-Duckham Vertical Retort and Oven Construction Co. (1920), Ltd. Remarkable progress has been made in the design and construction of coke-ovens, particularly during recent years, and this plant represents the latest of its type, it being especially economical in operation and maintenance. In addition to producing a high-grade coke of uniform quality, this plant recovers from the gas evolved in the ovens valuable by-products in the form of tar, ammonium sulphate, motor fuel, toluole, and naphthalene; the sale of these

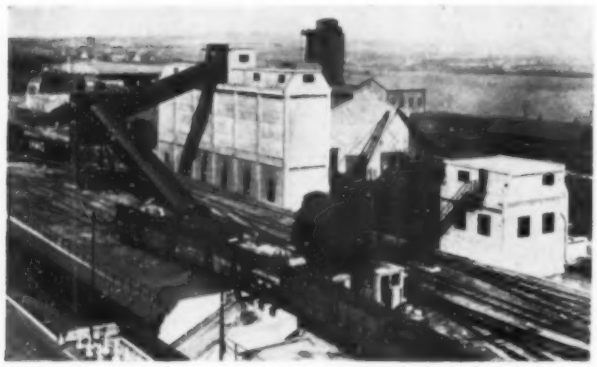
contributes towards lower manufacturing costs of coke, which advantage is ultimately passed to the pig iron.

A portion of the gas after by-product removal is used in heating the ovens and for steam-raising, whilst the rest is available for use in industry and for domestic purposes. It has a high calorific value, and is therefore particularly suitable for heating and power raising.

coke-quenching car, and an electric locomotive for the latter. All these machines operate on direct current at 220 volts, and are fitted with the latest type of Igranic time control. Press-button sequence control is fitted to all conveyers and connected machines. The door extractors are designed to handle the self-sealing " Stayclean " doors with which the battery is equipped.



Cross-sectional view of plant, showing oven battery and machines, sulphate-house and coal and coke-handling plant in elevation.



Coal reception and handling plant, blending bunkers, crusher-house, coke tipper, and coke wharves.

General Description of Plant

Coal is received in railway wagons, which are marshalled on the plant sidings into trains of suitable classes before passing forward to a wagon tipper for discharge into the coal-receiving hopper. The sidings are gravity operated, and will accommodate 24 hours' supply of coal—*i.e.*, eight hours' crushing capacity. From the hopper coal is delivered by a system of belt conveyers to a range of six blending bunkers of 1,500 tons total capacity, from which it is discharged over revolving tables which regulate the proportion of each class of coal on to a belt conveyer to the crushing plant. Five grades of coal were being used when the plant was inspected recently: Durham, Welsh, and three from local mines. The crushers are of the Pennsylvania hammer-mill type, and by them the coal is finely pulverised and intimately mixed. It is afterwards conveyed by a system of belts to the ovens storage bunker, which accommodates 2,000 tons of coal.

The ovens are of the W-D Becker regenerative combination type, and are capable of producing 5,000 tons of coke a week. They are heated by means of coke-oven gas, but are designed so that they can be operated with blast-furnace gas merely by the addition of blast-furnace gas mains.

The oven machines comprise a coal-charging car, a combined pushing, levelling, and door-extracting machine, a combined coke side-door extractor and coke guide, a

Coke from the ovens is quenched at a central station and discharged on to an inclined wharf capable of holding the contents of five ovens. Thence, after cooling, it is conveyed to the screening stations, where the blast-furnace coke is separated from undersizes. These are subsequently rescreened into various sizes to suit different markets. The furnace coke is loaded into railway wagons for delivery to the blast-furnaces, while the small coke and breeze are delivered into bunkers located over the railway sidings. A separate small wharf is arranged to deal with " purchased " coke, which passes through the same screening process.

The by-product plant is of the semi-direct type, with equipment for the recovery of crude tar and sulphate of ammonia. Plant is installed for the recovery of crude benzole and its rectification to motor spirit, toluole and naphthas. A special continuous still is incorporated in the benzole rectification plant for the removal of carbon disulphide from the unwashed product.

After leaving the benzole scrubbers, the gas stream is divided; a portion is returned to the ovens for heating purposes, and a quantity of that remaining is consumed at the steam-boiler plant. The remainder passes to a surplus gas main. A 100,000 cub. ft. gasholder is installed, to maintain gas pressure and for storage.

The Oven Battery

The 53 ovens are arranged in a single battery, with the ovens bunker at one end; each oven being 40 ft. 8 in. long between doors, 13 ft. high, and having an average width of 16 in. The holding capacity of each oven is 651 cub. ft. The battery is capable of producing 5,000 tons of furnace coke a week, when carbonising coal with 12% moisture content.

The oven brickwork from the pad upwards is constructed entirely of first quality silica, excepting only the filling in the regenerators and the end walls adjacent to the pinion walls. Waste-gas flues, constructed of concrete and lined with firebrick, are built along each side of the battery and connect into a single flue leading to the stack, which is placed at the ovens bunker end of the battery on the coke side. The stack is 250 ft. high, and is large enough to deal with the gases from an ultimately extended battery of 64 ovens.

Heating System

The heating system of the W-D Becker oven consists of a series of vertical flues on each side of each oven, with two regenerators built under each series of vertical flues. When employing coke-oven gas as the heating medium, both regenerators are used for preheating the air for combustion. The coke-oven gas is delivered through a horizontal gas conduit carried in the brickwork between the top of the regenerators and the bottom of the vertical flues. From these conduits the gas passes by means of a calibrated nozzle and vertical duct into the bottom of each vertical flue, where it mixes with the preheated air.

The air and gas come together with streamline effect, and the combustion zone is evenly distributed throughout the height of the vertical flues. The products of combustion are then collected from the top of each group of four vertical flues and are carried over the top of the oven by means of cross-over flues. From these flues the waste gases are distributed into an equivalent number of vertical flues on the other side of the oven, exactly opposite the flues up which they have travelled. They then travel down these flues and into the two regenerators immediately below, through which they pass to the waste-gas flues, giving up heat to the chequer-filling in transit.

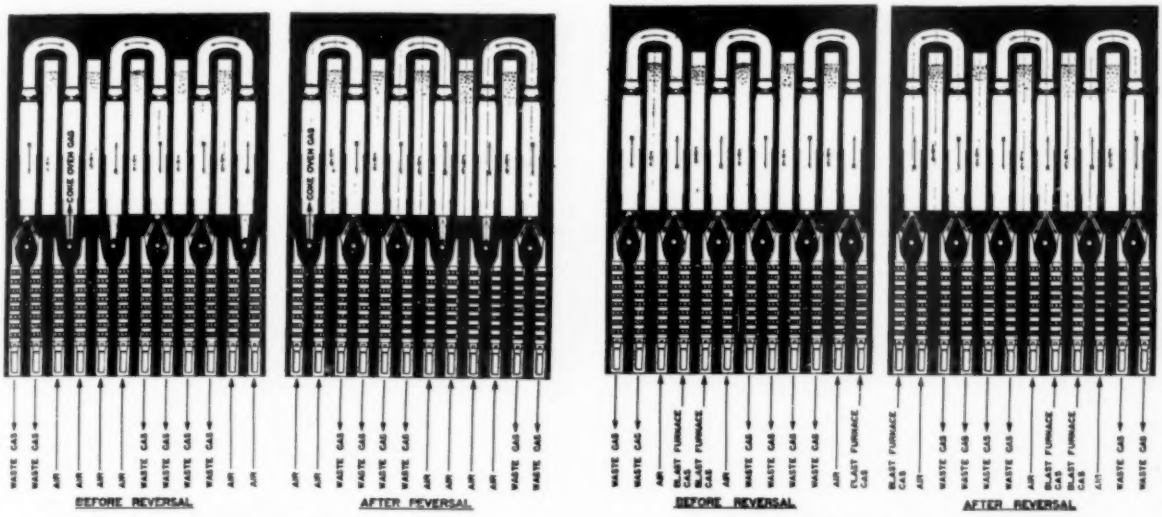
Upon reversal, which is automatically controlled, the air travels up those regenerators through which waste gas has previously passed, meets the coke-oven gas, and combustion takes place upwards; the products of combustion travel through the cross-over flues, and down the flues up which the burning gas has previously travelled, finally passing out through the corresponding regenerators.

This arrangement of heating ensures that the travel of gases throughout the system is short and unidirectional, and consequently there is a low-pressure differential and absence of leakage. The velocity of gases is slow and uniform, so that excellent regulation can easily be obtained.

The reversing valves are designed so that with the provision of blast-furnace gas mains, any or all of the ovens can be heated by means of blast-furnace gas. In this case air will travel up one of the two regenerators, and gas up the other. Both the air and the gas will enter the bottom of their respective regenerators from both ends of the oven at the same time. After passing through in an upward direction and absorbing heat from the chequer-filling in transit, they will leave the top of the regenerator and enter the bottom of the vertical flues. From this point onwards the flow of gases would be the same as when coke-oven gas is used.

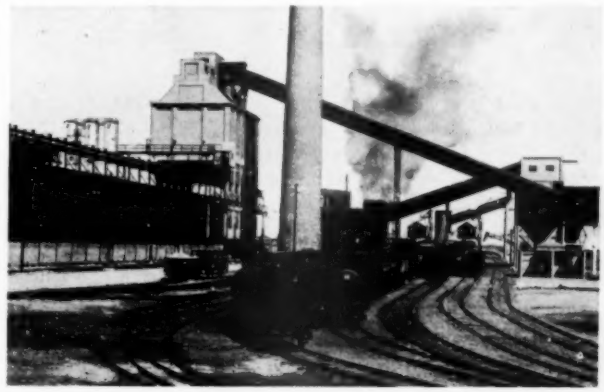
Battery Control

The reversing machine, which is located in the battery-control room, is situated at the ovens bunker end of the battery. Normally operated by an electric motor, the machine is provided with a steam-operated stand-by-which can be used in case of a failure of power. Its move, ments are controlled by an electric clock, which can be set to operate the machine at various time intervals. An emergency push-button control is provided, and should the clock fail to operate the reversing machine at the predetermined time, an automatic time switch sounds an alarm. Also in the battery-control room is a hand-operated decarbonising machine which raises the air lids on the gas guns to remove carbon deposits.



COKE OVEN GAS FIRING. BLAST FURNACE GAS FIRING.

Diagram showing flow of air and gases through the heating system of the W-D Becker coke-oven when underfiring with coke-oven gas or blast-furnace gas.



Coke side of battery, ovens bunker, handling plant, and coke side screening stations.

Coal Blending, Crushing and Handling

Coal is brought into the works in railway wagons, which are discharged into a 50-ton reinforced concrete receiving hopper by means of an electrically operated cradle-type wagon tipper. The receiving hopper has two hoppered outlets, which discharge to two jigging feeders, which deliver on to a 32-in. wide inclined belt conveyer. This conveyer delivers the coal on to another 32-in. inclined belt conveyer, which runs at right angles to the first conveyer and takes the coal up to the top of a range of six blending bunkers.

The blending bunkers are constructed as a monolithic reinforced concrete structure, and each has a capacity of

Battery top, showing charging car, gas ascension pipes, and ovens bunker, with spillage coal hoist.

250 tons of coal, giving a total capacity of 1,500 tons. The outlet from compartments discharge to a revolving feed-measuring table, and thence on to a 32-in. belt conveyer, which delivers the blended coal into a Pennsylvania hammer-mill crusher.

There are two crushers, one of which acts as a stand-by, which reduce the coal so that 80% passes through a $\frac{1}{8}$ in. mesh. From the hammer-mill a further system of three 32-in. belt conveyers, running at right angles to each other delivers the pulverised intimately mixed coal to the top of the ovens coal bunker. Here it is received by a shuttle belt conveyer, which distributes it in the bunker as required. The ovens coal bunker is of reinforced concrete and has a capacity of 2,000 tons of wet crushed coal.

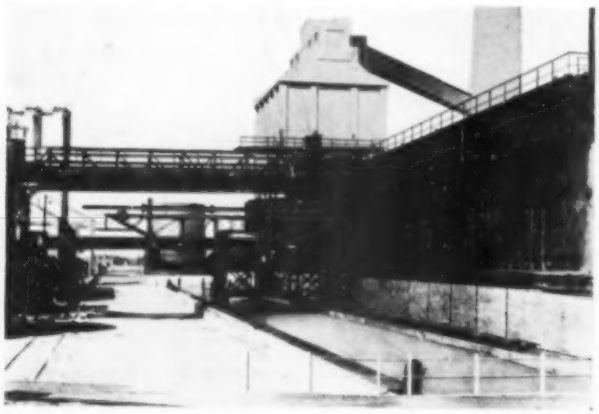
Oven Charging

An electrically propelled coal-charging car runs on rails along the top of the battery. It has four steel hoppers, each fitted with an electrically operated agitating gear and an adjustable measuring device. A weighbeam of 50 tons capacity is provided for weighing the coal in the car before charging. It is fitted with a ticket-printing device to record the weights.

Coke Pushing

When carbonisation of the coal charge is complete, the coke is discharged by the pusher machine into a coke-quenching car. This machine, which runs on rails, carries a ram and a door extractor with slewing action, designed for handling the self-sealing doors. The travel of the machine, the pusher-ram, the leveller-bar, and the door extractor are all operated by separate electric motors.

Pusher side of battery, showing pusher machine, "Stayclean" doors and gas collection and suction mains.



Coke Discharging and Quenching

The coke is received in a coke-quenching car, which runs on a standard gauge track. It is hauled by an electric locomotive on which are mounted two air compressors for operating the gates on the coke-quenching car. One of these air compressors acts as a stand-by. An electrically operated combined door-lifting machine and coke-guide is provided, running along a track on the coke side platform. This serves to remove and replace the doors on this side of the ovens, and also forms a guide and support through which the coke is pushed into the quenching car. The coke-quenching car, with its load of hot coke, runs into a quenching station, where it is sprayed with water.

After quenching, the coke is discharged for cooling on to an inclined coke wharf, 160 ft. long. This wharf is situated alongside the quenching car track, and is constructed of reinforced concrete covered with hard burnt blue tiles set in cement. After cooling, the coke is fed through hand-operated regulating gates on to a 42-in. belt conveyer, which takes it to the primary screening station.

Coke Screening and Handling Plant

At the primary screening station a double-deck "Gyrex" screen separates the run-of-oven coke into two sizes—furnace coke over 1 in. and unscreened small coke 0–1 in. The top deck effects preliminary screening, while final separation is carried out on the lower deck. The furnace coke is discharged on to a boom loader, which delivers it into wagons. The wagons are subsequently weighed before despatch to the blast-furnaces.

Gas Collecting System

The crude gas leaves the ovens at the pusher side and passes into the collecting main. Sprays for liquor flushing are provided, and the collecting main is equipped at each end with a liquor-sealed bleeder. From the collecting main the gas and liquor pass into a suction main, which terminates at a downcomer before the primary coolers. The flushing liquor, which runs in a closed circuit, is returned at the downcomer to a liquor-flushing and separating tank of some 36,000 gals. capacity.

Gas Cooling and Tar Extraction

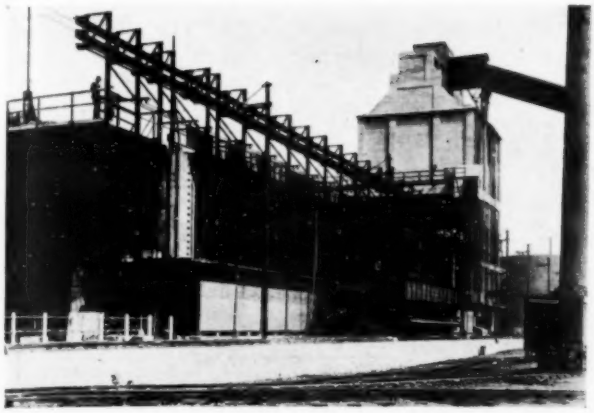
The gas passes from the ovens to the primary coolers, which are of the vertical tube water-cooled type in which tar and ammoniacal liquor are condensed. From these primary coolers, the cooled gas is passed by the exhausters to a range of W. W-D Electro-Detarrers. These are of the vertical-tube, suspended-wire electrode type, and are three in number. Two are normally in operation with one as stand-by. They stand on the roof of a generater-house, in which are installed two generator sets for generating the high-tension electrical current by the discharge of which the tar fog is precipitated in the detarrers. The drainage from the detarrers is passed into the tar- and liquor-separating tank.

Ammonia Saturators and Acid Separaters

From the electro-detarrers the gas passes through a reheater before entering the ammonia saturators. These vessels are lead-lined, and provided with lead cracker pipes. The gas bubbles through the sulphuric acid bath contained in the saturators, and passes through separators, where any traces of entrained acid are removed. Two air compressors are installed, one electrically operated and the other, which acts as a stand-by, steam-driven. These supply compressed air for the sulphate and acid ejectors and for elevating acid from storage to feed tank.

Sulphate Drying and Bagging

The wet sulphate is ejected into one of two drain tables, consisting of cast-iron boxes lined with lead. After draining, it is dried in centrifuges, each having a capacity of approximately 600 lb. of sulphate. From beneath these driers the



Coke-quenching station during quenching, showing also main coke wharf and discharge gates.

sulphate is fed by means of wooden chutes on to a scraper conveyer, which delivers it into a " Wilton " drier, which both dries and neutralises the salt. This apparatus is specially adapted for using ammonia gas as a reagent for neutralising, instead of ammonium carbonate. A feature of this plant is the equipment installed to prevent any dust nuisance arising from the draughting of the " Wilton " drier.

The dry neutral sulphate is discharged into an elevator, which feeds it into a bagging hopper of 30-cwt. capacity, provided with an automatic bag-filling and weighing machine, equipped with a self-registering device.

Ammonia Still

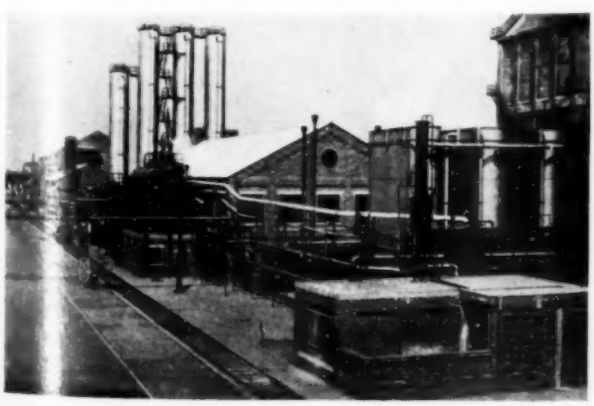
The ammonia liquor condensate from the primary coolers is distilled in a still which has a capacity of some 3,000 gals. of ammonia liquor per hour. An orifice type meter is provided for measuring the ammonia liquor entering the still, which is also equipped with a waste-liquor trap. Lime-slaking and mixing apparatus is provided, while two open impeller type pumps, one of which is a stand-by, are installed for supplying the limewater to the still.

From the fixed section of the ammonia still a portion of the ammonia vapours passes through special apparatus for preparing ammonia gas for the " Wilton " neutraliser and drier. This comprises a small column and a reflux condenser from which the liquor is drained back into the ammonia still. The rest of the ammonia vapours pass direct into the gas stream immediately before it enters the saturators.

Benzole Recovery

After leaving the saturators and acid separators, the gas passes through a tower type final cooler, packed with wooden hurdles, where the naphthalene is removed. After final cooling, the gas is debenzolised in three-hurdle type tower scrubbers, and passes upwards through the scrubbers, meeting a descending stream of wash oil which absorbs the crude benzole. This oil, enriched with benzole, is delivered into a specially designed distilling apparatus provided with the necessary heat exchangers, condensers, and coolers.

Primary coolers, by-product house, detarrers and benzole scrubbers, with ammonia distillation plant in foreground.



The crude benzole vapour passes from the still through the vapour-to-oil heat-exchanger and a closed cooler into a separator for removal of water. This separator is provided with sight overflows for benzole and water. The crude benzole flows into a storage tank of 10,000 gals. capacity. From here it is delivered by a steam-driven pump into the steam-heated tank of the crude benzole still, which has a capacity of 8,300 gals., and thence through the rectifying column of this still. The crude heavy naphtha from the crude still flows to a tank of 5,000 gals. capacity.

The once-run product is raised by a steam-driven pump to an overhead receiving tank, from which it is fed through a constant level tank, a heat exchanger, and a vertical tube type heater to a Barbet type continuous still for removal of carbon disulphide. The carbon-disulphide-free benzole passes through the heat exchanger and a horizontal tube type final cooler to a 10,000-gal. storage tank. From this storage tank it is normally delivered to an agitator of 4,600 gals. capacity. After acid and soda washing, the washed benzole is either delivered to a 10,000-gal. washed benzole storage tank or direct into the steam-heated tank of the final rectification still. Thence it passes through the final rectification column. The rectified benzole passes through a dephlegmator, a final cooler and a water separater to two receiving tanks, whence separate pipe-lines are carried to the two 5,000-gal. compartments of a motor-fuel running tank. From here motor fuel is pumped to a storage tank of 45,000 gals. capacity.

The 90's toluole and refined heavy naphtha from the final still are each delivered into separate storage tanks of 5,000 gals. capacity.

Gasholder and Mains

After leaving the benzole scrubbers, the gas passes through an orifice type total gasmeter. Fuel gas is then passed by branch lines to the ovens and the boilers. A further connection for surplus gas is provided, so that a main may be installed to distribute supplies to other consuming points. A further line is provided to a gas bleeder 100 ft. high. The surplus gas enters a single lift gasholder of 100,000 cub. ft. capacity. The surplus gas connection and the bleeder line are fitted with automatic valves controlled by the position of the holder.

Large Platinum Nugget Found

A large nugget of platinum weighing 2,345 grams (75 oz. troy) has been found by a group of Soviet prospectors in the Kosynsk goldfield in the Urals. The group were looking for gold along the banks of the river when they made the lucky find.

The purity of the nugget has not yet been ascertained, but at prevailing world prices it is valued at about 5,000 gold roubles. An idea of the extraordinary nature of the find may be gauged from the fact that the entire world output of platinum amounts to about 300,000 oz. annually.

119th Blast Furnace in the Soviet Union

The second blast furnace of the Novo-Tula Metallurgical Combine (Moscow Province), and the 119th in the Soviet Union, was blown a few days ago. The furnace and its mechanisms are reported to be working without a hitch.

Built in accordance with the latest technical requirements the blast furnace has a volume of 930 cubic metres, and a capacity of 800 tons of pig iron a day. It is fitted with improved measuring and signalisation apparatus. The furnace was built at a much lower cost and much more efficiently than the first blast furnace of the Novo-Tula Combine.

Empire Exhibition in South Africa

CONSIDERABLE enthusiam has been aroused by the Empire Exhibition which opens this month in Johannesburg. Not only is this manifest in South Africa, but in the United Kingdom, and in the Dominions and Colonies. The keynote of the Exhibition is the progress of South Africa and of the Empire during the last fifty years. The Exhibition grounds cover an area of over 100 acres and over 40 pavilions are erected.

Last year marked the 25th anniversary of the Union of South Africa, and these important years have seen a tremendous increase in agricultural products and mineral development. During this period the European population has increased by over 50 per cent. and the native population by over 40%. To-day the Europeans number some two millions and the non-Europeans about six and a half millions. The Union is passing through a period of great prosperity, based, of course, on the high currency value of gold. The Railways and Harbours administration have in the past two years worked off a deficit of £3½ million and in addition have found it possible to carry forward a substantial surplus for the current financial year, even after making large contributions towards staff funds and making substantial reservations for replacements, etc. Following on this great production of gold and other metals, there is, of course, a great business to be done in machinery and stores; imports of mining requirements in 1934 were 145% of the 1929 returns and £400,000 greater than in any previous year. This increase continued in the first half of the year 1935, and it is likely to be a constantly expanding market. The United Kingdom is fortunately the best customer of the Union and is also her principal supplier; there is nothing so sound as a two-way trade.

Johannesburg, which houses the Exhibition, is the centre of the Union's prosperity. It first came into prominence in 1886 through the discovery of gold on the Witwatersrand and at that time there were merely a few tents and reed structures erected on the open veldt. To-day its population is 400,000 and is steadily increasing. It is the largest and most important city and commercial centre in the Union.

The Exhibition is the first Empire Exhibition to be held outside Great Britain. It is whole-heartedly supported by the Union of South Africa Government and by our Government, and, in view of its industrial possibilities, it is being supported by many United Kingdom manufacturers who desire to increase their export trade, and of these are notable steel manufacturers which include The English Steel Corporation, Ltd., Thos. Firth and John Brown, Ltd., and Firth-Vickers Stainless Steels, Ltd.

Each of the Companies occupy space in the hall of heavy machinery. The English Steel Corporation, Ltd., are exhibiting steel castings for stamp batteries for gold mines; railway material including wheel discs, tyres, axles, springs, connecting rods, etc.; drop forgings, showing stages in the manufacture of a drop-forged crankshaft, and crankshafts as supplied for many record-breaking aircraft and automobiles; special alloy steels and tool steels and a wide range of engineer's small tools.

A selection range of the products of Thos. Firth and John Brown, Ltd., include finished engineer's small tools consisting of high-speed twist drills, files—including the new "Millenicut" file—circular metal cutting "Insto" saws with inserted teeth, the Firth Hardometer hardness testing machine, new and improved forms of high-speed milling cutters and reamers, drills, wood cutting saws, band saws and machine knives, hacksaw blades, and lathe tools, both solid and butt welded. The heavier side will be represented by several examples of forge craft, whilst castings for crusher plant, tyres, axles, die blocks, springs, beater bars, and a range of mining drill steels will complete the display of this Company.

The "Staybrite" super rustless steel exhibits on the stand of Firth-Vickers Stainless Steels, Ltd., will pay tribute to the remarkable progress made in the adaptation of this metal for almost every conceivable purpose. The stand will feature a most arresting display of "Staybrite" spoons, forks, Firth stainless steel cutlery, "Staybrite" steel sinks, saucepans, bowls, sponge racks, "Staybrite" steel back brush sets, cuff links, cigarette cases, door furniture and fittings, cruets, garden implements, yacht fittings as well as the various forms in which it is supplied by the manufacturers, namely, bars, sheets, forgings, castings, strip, wire, plate, angle and sections, tubes, drop stampings, as well as nuts, bolts, rivets, wire mesh, and other semi-fabricated forms. Technical representatives will be in attendance to inform interested inquirers about any question which they may wish to raise in regard to the application of Staybrite steel.

Important New Developments in Nova Scotia Gold Mining

THE most extensive goldfield in Canada, though not the most productive at present, is in Nova Scotia. It extends the full length of the Province's mainland, a distance of 300 miles, and underlies over half its area. There are over a hundred separate gold districts, from each of which at least a small production of gold is recorded. In several of these districts work is now under way that promises to put Nova Scotian gold mining on an entirely different footing from that of the past. The typical gold deposits mined up to the present have consisted of small, rich deposits, which only occasionally have resulted in profitable operations. The Nova Scotian miners have become highly skilled in finding and mining these rich pockets; but they have failed to find and develop any of the large deposits of more moderate grade that alone can give permanence to the industry.

During the past year a number of gold operators from Northern Canada and elsewhere, accustomed to resist the lure of small spectacular deposits, have been searching in Nova Scotia for evidences of larger and more consistent bodies of ore. Some of these have found deposits to their liking, and are developing them in a consistent way to prove or disprove their merits. At Goldboro, on the coast 110 miles east of Halifax, a mine of moderate dimensions has now been proved by this means—the first to be thus established in the province. At Goldenville, Ventures, Ltd., has in hand a similar investigation at depth of deposits that have already yielded several million dollars from superficial workings. The Caribou district is being similarly examined in a thorough way by Consolidated Mining and Smelting Co. Other such attempts to prove large-scale deposits are being conducted by companies not so widely known as these two.

The Minister of Mines of Nova Scotia, Hon. Michael Dwyer, a mining engineer, has instituted practical measures with a view to forestalling the boomster practices that have commonly beset and hindered the progress of every gold area in this and other lands. He requires each and every applicant for a gold mining lease or the transfer of a lease to produce not only evidence of his good faith but of a sound plan of operations and of his financial and technical ability to execute these plans. This is a requirement of sound business practice, and there is no apparent reason why it cannot be applied both consistently and effectively by a government department.

Nova Scotia has one of the best-knit groups of mining men in the Dominion, in the form of the Mining Society of Nova Scotia, which is affiliated with the national body, the Canadian Institute of Mining and Metallurgy, and Hon. Mr. Dwyer has the solid support of the Society in his progressive measures on behalf of the gold industry of the province. Present indications are that the gold output of Nova Scotia will rapidly reach important dimensions, that under Mr. Dwyer's direction this development will be along sound lines, and that the dangers and repercussions of another ephemeral gold boom will be averted.

METALLURGIA
THE BRITISH JOURNAL OF METALS.
INCORPORATING "THE METALLURGICAL ENGINEER"

Institute Meetings Abroad

DÜSSELDORF

THIS month witnesses what might be termed a stampede to the Continent of the principal British Institutes concerned with metallurgical matters. The Institute of Metals, the Iron and Steel Institute, the British Cast Iron Research Association, and the Institute of British Foundry are holding or attending meetings abroad. Some of these associations have previously held meetings abroad, but this is the first time so many have arranged for members of the respective organisations to attend meetings abroad at or about the same time.

Apart from the Institute of Metals, which has held its autumn meeting in Paris, the tendency has been to meet in Germany, where the Iron and Steel Institute is holding its autumn meeting. Thus, a party of about 60 members of the British Cast Iron Research Association has visited about eight foundries in Germany. These foundries cover both jobbing and mechanised plants, special alloys, etc., and included the Krupp Foundries at Essen. This party, together with members of the Institute of British Foundrymen, who are attending the World Foundry Conference at Düsseldorf, attended the opening of the Foundry Congress and Exhibition. The arrangements in each case, however, allow for an extension, so that members may be able to take part in the Iron and Steel Institute meeting in Düsseldorf.

There is much to be said for holding meetings abroad, particularly as the development of knowledge, whether scientific or technical, should have no national limits, each country depends more or less on development abroad as well as within its own boundaries. More than anything, however, these meetings bring about friendly discussion with people in neighbouring countries who are faced with similar problems and quite apart from the mutual advantage gained from such discussions, which is frequently considerable, the friendly feeling engendered is probably of more vital importance, since it tends to promote international good will. The only difficulty seems to be that the organising of these meetings has been carried out so thoroughly that members who do not confine their activities will be somewhat exhausted by the efforts of the various organisations to make their stay interesting and profitable. The meetings to be held at the time of writing are those at Düsseldorf, and some reference to the importance of this city will be of interest.

To attempt to sum up Düsseldorf's industrial activities in a few simple words is impossible; they are manifold. It enjoys a reputation as an artistic and garden city, as well as being a seat of an important industry and a productive market. With excellent transport facilities by land, water, and air, Düsseldorf is indeed in a favourable position. The most important industry of the town is the manufacture of iron, steel, and other metals in all forms. The real heavy industries are mainly concerned with the manufacture of semi-finished iron and steel, rolled sheets and wire, tubes, cast and forged machine parts of all sizes, bridges and ironwork of all descriptions. The manufacturers of the town have a world-wide renown—for example, the Vereinigte Stahlwerke and Mannesmannröhen-Werke, who are known all over the world, have their head offices and most important works in Düsseldorf.

The machinery works in Düsseldorf are extraordinarily numerous, and produce a wide variety of machinery which has a very good reputation. Here also is a whole series of famous names, such as Demag, the old firm of Haniel and Lueg—now the Düsseldorf division of the Gutehoffnungshütte, Oberhausen A.-G.,—and Schiess-Defries, to mention only a few. Railway coaches are made by undertakings like Hohenzollern, Gebr. Schöndorff, and Vereinigte Westdeutsche Waggonfabriken, while heavy commercial automobiles are made by the Deutsche Lastautomobil-Fabrik Daag. The manufacture of iron and metal wares, enamelled ware, and fine mechanical tools, is also undertaken by works in the town. The precious metal industry is represented chiefly by the manufacturers of silver cutlery. But it is impossible to enumerate in a short space the manifold articles made in the town of Düsseldorf and its surroundings. It is one of the largest centres of the West German steel and machine industry. It is the headquarters of the Verein deutscher Eisenhüttenleute, and of the Kaiser-Wilhelm-Institut für Eisenforschung, and from a metallurgical point of view is an important centre for scientific and technical development.

In addition to Düsseldorf, many other important towns are included in the visits; mention may be made of Dortmund, a town of over 540,000 inhabitants, and which covers the second largest area of any town in Germany. With its enormous works, mines, machine manufacturing works, constructional shops and other large industrial plants, it is an important modern industrial city, as well as the centre of the economic life and traffic routes of the province of Westphalia. Duisburg, another large industrial and commercial city, possesses the largest inland port of the world. The port of Duisburg, including the waterways, covers 2,541 acres, while the turnover approximates 42 million tons per annum. It is the only town in Europe to own a shipping exchange. Other branches of industry include iron and steel works, bridge and constructional shops, machine manufacturing works and shipyards. Situated in the centre of the Rhenic-Westphalian industrial district is Essen, a city of over 600,000 inhabitants, and world-renowned as a great centre of industry of the Krupp Works and of important industrial associations. Although an industrial centre, Essen is a charming residential city. Köln, Krefeld-Merdingen, and Saarbrücken, also included in the visits, will add considerably to the interest of members and friends taking advantage of the facilities provided, and will assist in making the visit to Germany a memorable one.

It is hoped that these meetings will hasten the time when contemporary associations abroad can make it convenient to hold occasional meetings in this country, in order that the excellent facilities provided for the members of British organisations may be reciprocated in a worthy manner.

Some important articles and descriptions of works visited on the Continent have been unavoidably held over for publication in the October issue.

The Canadian Mineral Industry and its International Importance

CANADA, as a young and sparsely settled country with a capacity to produce many commodities greatly in excess of her own requirements, is dependent on foreign trade to a far greater extent than many of the more densely populated countries. The Dominion has, therefore, suffered greatly from post-war economic changes which have largely destroyed international trade and, in a recent broadcast, the Minister of Mines of the Dominion, the Hon. T. A. Crerar, M.P., stressed the international importance of the Canadian mining industry.

Since 1929 there has been a very serious fall in the value of Canadian agricultural exports. Exports of wheat and wheat flour, for instance, dropped from $302,000,000 in value in 1929 to only $156,000,000 last year. This breach in the export trade would have exercised a very serious effect upon the economic conditions in the Dominion, but for the fact that this breach was filled with products of the mining industry which had then reached the point at which it could meet the rising demand for industrial metals of electrolytic purity. The international trade in mineral products is not hampered to the same extent as is the commerce of other commodities. It has consequently become a sustaining factor in the external trade of Canada, which has more than her proportionate share of the world's mineral wealth together with an abundance of waterpower for its cheap development.

The degree to which the mining industry has arrested the decline in Canada's external trade during the depression, and remarkably rapid growth in Canada's exports of gold and non-ferrous metals in recent years, suggests that in the development of mineral resources the Dominion possesses the means of securing an era of prosperity as great as was enjoyed during the development of the western farm lands.

Ten years ago, the annual exports of primary mineral products—*i.e.*, products in raw or slightly processed forms only, amounted to less than 9% of the value of Canada's total exports; last year they contributed more than 25%. They rose from $116,000,000 to $210,000,000. Canada's exports of primary farm products declined, however, during the same period from 50% of the export total to 31%; or from $674,000,000 to $256,000,000. Although agriculture remains Canada's primary leading industry the development of the mineral industry is her great opportunity at the present time. Her export trade in metals reached a total value of $200,000,000, representing 90% of the Dominion's entire output of such metals as gold, nickel, silver, copper, zinc, lead and platinum. Domestic consumption is relatively quite small; for instance less than 1% of the Canadian nickel output is utilised in the Dominion. After supplying her own needs Canada exported last year 200,000 tons of copper, 148,000 tons of zinc, 147,000 tons of lead and 71,000 tons of nickel.

The magnitude of the British demand for metals if of prime importance to Canadian producers. In 1935, for example, the United Kingdom imported from Canada 84,000 long tons of pig lead, 97,250 tons of zinc, 70,000 tons of electrolytic copper as well as 12,250 tons of copper in the form of rods or other shapes. Practically all of the nickel consumed in the United Kingdom is derived from Canadian ore. Sales abroad last year of gold, silver and platinum metals equalled 75% of Canada's wheat and wheat flour exports. Sales of copper realised $2,000,000 more than the exports of wood pulp, and sales of nickel more than combined exports of meat and dairy products. A study of the Canadian export trade statistics shows that eight out of the first 22 items, which together accounted for 75% of the total value of Canadian exports, were mine products. Furthermore, even with the exclusion of gold, Canada's exports of primary mineral products were sufficient in value to balance imports of such products as cane, sugar, cotton, tea, silk, coffee and rubber as well as most of the American anthracite.

Thus, the Canadian mineral industry is of great importance in the adjustment of the Dominion's international trade. In 1933, for the first time, exports of minerals and their manufactured products exceeded imports thereof, and this balance of exports has since been increased from $28,000,000 to $44,000,000. Exports of primary mineral products alone equalled in value almost 40% of the imports of merchandise for domestic consumption, whilst 10 years ago the proportion paid for in this way was only 12%. For this satisfactory condition Canada is indebted mainly to her growing production of gold and base metals. The product of her gold mines especially, figures prominently in her commerce with other nations. As gold is the only commodity for which an unlimited market exists at a more or less fixed price, the metal has proved especially important to the Canadian balance of international payments.

The Moscow-Volga Canal

THE Moscow-Volga Canal, now nearing completion, is one of the most important constructions of modern times. When completed in 1937 it will measure 80 miles, and will exceed the length of the Panama Canal by some miles. The construction of this canal solves three main tasks simultaneously. It will make the Moscow River navigable for large ships; it will provide the city of Moscow with the necessary water for domestic and industrial purposes, and it will raise the levels of the waters of both the Moscow and the Yauza rivers and improve their sanitary condition.

Actually, Moscow is situated upon a shallow river, which has precluded any serious thought of navigation, especially in summer, when regular transport is seriously obstructed by shoals and sandbanks. The insufficiency of water has always had a deleterious effect upon extensive city improvements owing to pollution. When the canal is completed and the waters of the Volga enter the Moscow River every person in Moscow will be assured of an adequate supply of water. With such an increased water flow, the Moscow River will be practically unrecognisable. Moscow will be converted into a sea-port. Through the Marinsk river system and the recently constructed Baltic-White Sea Canal, it will be connected with the White Sea, and through the Lagoda and Neva Rivers with the Baltic Sea. Steamers will be able to travel from Moscow, down the Volga, to the Caspian Sea. When the Volga is ultimately connected with the River Don, by means of the canal now under construction, ships will be able to follow a deep water route to the Black Sea. Thus it is anticipated that Moscow will become an important port.

The Moscow-Volga Canal will reduce the distance between Moscow and Gorky (Nijni-Novgorod) by about 67 miles, and between Moscow and Rybinsk, the beginning of the Marinsk waterway system, by about 688 miles.

In order to gain an idea of this vast undertaking, a comparison between this and other canals can be made. The North German Canal and the Manchester Ship Canal are both considerably smaller than the Moscow-Volga Canal both in length and in excavation volume involved. The Panama Canal exceeds it in volume of excavation, but it is shorter in length, while the recently constructed Baltic-White Sea Canal is shorter and the amount of ground excavated is seven times less.

The Baltic-White Sea Canal was the first project in the task of linking the sea to which the U.S.S.R. has access. The Moscow-Volga Canal is the second, and construction is particularly complicated because of the considerable elevation which begins a few miles from the Volga and extends for more than 25 miles along the course of the canal. This watershed makes it impossible to have a continuous one-level water corridor between the Volga and Moscow, and will necessitate the building of a stairway of locks, and it can be considered the largest mechanised construction project of modern times.

The Application of X-Rays to Metallurgy.—Part III

By C. HUBERT PLANT

In this, the final of the short series of articles on the application of X-rays to metallurgy, the author deals with the practical side of the subject, giving particular attention to the X-ray apparatus and to the results obtained from X-ray photography.

A GENERAL idea has now been given of the theory underlying the principles of X-ray analysis, and it will now be useful to consider shortly the more practical side of the subject—the general arrangement of the apparatus required in order to produce X-ray photographs. It is proposed to deal with these matters in general, and not to describe any particular instrument, as there are several makes on the market, and so far as the author is aware any and all of them may be equally excellent and capable of the work they are called upon to do.

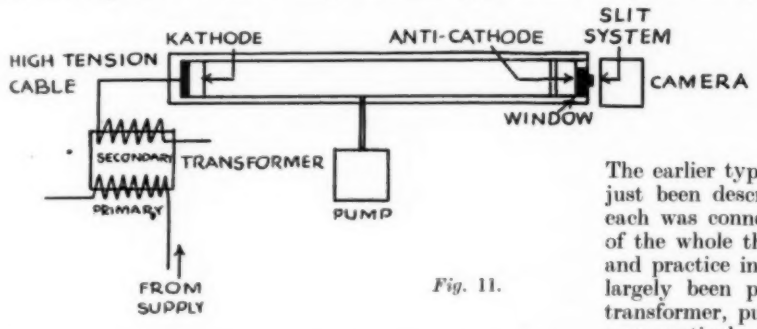


Fig. 11.

First, and most important of all, of course, is the X-ray tube itself. There are many types of tube, but essentially they all consist of a glass or steel tube in which is placed at one end the cathode or discharge end of the tube, and at the other the anti-cathode which is removable and interchangeable. Anti-cathodes may be of copper, cobalt, iron, tungsten or manganese, dependent upon the type of radiation that is required. The choice of suitable radiation is of the utmost importance, and it is essential that the absorption co-efficient of the alloy for X rays should be low. For metallic nickel, for example a copper or manganese target is the best, but copper radiation is quite useless for alloys consisting chiefly of iron, as the absorption of the radiation by the alloy is too great for any useful results to be obtained. For ferrous metals a cobalt radiation is by far the best though manganese will give very good results. When Laue photographs are required, tungsten is the general anti-cathode used.

In close proximity to the X-ray tube, the transformer should be arranged. Current will be taken by the transformer at 220–230 volts, according to the standard pressure of the supply, and it may be either A.C. or D.C., though in the latter case a suitable converter will also have to be installed. The discharge at the cathode end of the X-ray tube will be from 60,000–80,000 volts, so that the transformer will have to be capable of dealing with this. The high-tension current from the secondary coil of the transformer is passed to the cathode end of the tube by means of rubber-sheathed cables, and usually earthed metal shields are fixed to the tube. The cathode is usually cooled by some means, but the anti-cathode must of necessity be water-cooled. The anti-cathode is placed immediately in front of the "window," which is composed of a very thin plate (about 1/40 mm.) of aluminium or nickel foil. Finally a mercury vapour pump is required to maintain complete evacuation of the tube, and this also is placed reasonably close to the tube itself.

A great deal has been experienced in the past of the dangers accruing to the human body from X-radiation, and in the early days of pioneer work, mainly in connection with medical work, very serious injuries have been caused by X-ray burns, in some cases with fatal results. It therefore became the practice to surround the whole of the more primitive X-ray installation by a lead tank, because X-rays will not penetrate lead. Now, however, it is usual to incorporate a lead shield in the X-ray tube itself, so that there is absolutely no danger from undesired radiation, and no biologically harmful rays are able to escape. No one need, therefore, have the least doubts that work with a modern X-ray apparatus is at all dangerous.

The earlier types of apparatus were built up much as has just been described—each unit was a unit in itself, and each was connected with the central and important part of the whole thing, the X-ray tube. Now, however, skill and practice in the manufacture of these instruments has largely been perfected, and the whole apparatus, tube, transformer, pump and all connections, is enclosed in one comparatively small unit, though each independent part is easily approachable. It has now been realised that there are certain factors which make for not only ease of manipulation but which will go a long way to increasing the popularity of this adjunct to laboratory installations. Some of the more important of these factors are, in the order of importance—there should be entire protection from the dangers of X-ray burning, as well as protection from any risk of shock from the high-tension cables. Next, and this has only been realised in very recent years, the apparatus should be so designed that it can be operated without continuous attention from the metallurgist. That is to say, that it can be set up, and exposures taken which may last anything from 10–40 minutes, without someone having to stand by all the time. It should also be as simple and as fool-proof as possible, and what is also important, it should not occupy too much space. The author has seen some of the older arrangements of apparatus which almost required a laboratory in themselves, but modern apparatus is very different. Finally, and this has only been possible since quite recently, it should be capable of being transported, in fact there are now on the market actual portable X-ray outfits which may be taken to the specimens to be photographed, instead of the specimen having to be fixed into the apparatus.

Fig. 12.

The general arrangement of the apparatus as just described is shown diagrammatically in Fig. II, and some idea of the manner in which this is now combined into one whole will be obtained when it is stated that one modern make of apparatus weighs only about 70 lb. and occupies an overall space of about 3 ft. × 2 ft.

The only other accessory which it is necessary to mention to complete the installation is the camera, or cameras,

because some makes of instruments allow of two cameras to be operated in connection with one tube. There are several types of camera, but in all cases the principles are the same. The camera may have the "window" as an integral part, or the window of foil may be attached to the tube. In either case the slit is immediately behind it, the camera being adjusted exactly opposite to the anti-cathode end of the X-ray tube. The film is usually placed around the inside of the camera, and the specimen at proper optical length from the slit. Special X-ray films are used, and as already mentioned the time of exposure should be as short as possible depending upon the substance being photographed, and is usually from 10–40 minutes.

Such, shortly, is a description of the means adopted for taking X-ray photographs, and did space allow of it, complete details of various types of apparatus may be given. This, however, is hardly necessary since it is simple for anyone sufficiently interested to obtain very full literature and details from the firms who specialise in this class of work.

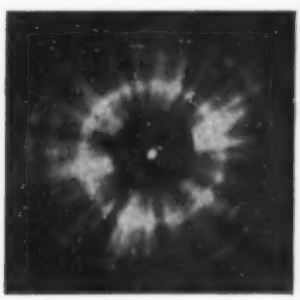


Fig. 13.

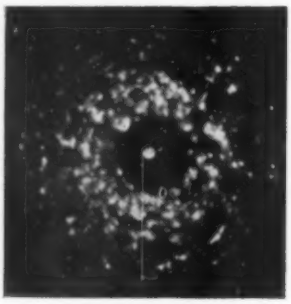


Fig. 14.

To turn now to the results obtained from X-ray photography, Fig. 12 gives some idea of the result obtained from a photograph of sodium chloride, and the lines characteristic of this salt are clearly distinguished. Supposing that it was not known what substance had been photographed, it would be very simple, by comparing the spacing of the lines, to arrive at once at the correct conclusion, because, as in astronomical spectrography, the lines formed from any substance, whether one such as common salt, or a metal such as iron or aluminium will give these characteristic spectrographs, and by spacing them as shown in the figure, information can at once be gleaned as to the composition of the substance. Not only this, but chemical analysis can actually be carried out. A particularly good example of this was described some little time ago by Dr. Pullin, Director of Radiological Research, at Woolwich. It was desired to know whether any solder was present in a minute fracture in steel. Accordingly an X-ray spectrum was obtained, and certain lines were found which were at once identified as belonging to iron, also a faint line in that position in the spectrum where it was known a line due to lead should appear. A graph of the spectrum was obtained, and supplied evidence that there was lead present in the steel fracture.

If on the other hand, photographs of the Laue type are taken, these will in turn produce a considerable amount of information. Fig. 13, reproduced from the author's book "The Metallography of Iron and Steel" shows the appearance of steel under a state of strain, while Fig. 14 gives the appearance of a photograph of steel when the crystals are large. It is impossible to lay down any hard and fast rules for recognising the meaning of these classes of X-ray photographs. Experience only will enable any metallurgist to ascertain the meanings of the photographs he has taken, but the important point which cannot be stressed too much is that when once a photograph of any known substance has been taken, under any conditions of working, etc., and such conditions are known, then all future photographs of similar substances under similar conditions will always be identical, consequently identification and the knowledge of what the photograph reveals becomes a simple matter. No two microphotographs will ever be the same—two specimens could not possibly be sectioned, polished or etched in exactly the same manner, and what is more fundamental no two pieces of the same class of steel, or any other metal will ever crystallise in exactly the same manner. No two pieces of exactly similar steel will ever give exactly the same chemical analysis, but they will always give exactly the same X-ray spectrograph or photograph, because of the important fact that one is photographing, not iron carbide, or ferrite, but the results are obtained from diffraction or reflection from the atomic spaces within the crystals, and these being almost the fundamental of the materials, cannot change. The author has been accused of being too optimistic on this same point before, but has not yet had reason to change any of the views now expressed. If space permitted, it would be possible to reproduce three spectrographs of sodium chloride, taken by three different authorities by three different classes of instrument, yet it is almost impossible to detect any difference whatever in all three photographs.

It will not be a good thing to leave the subject of the application of X-rays to metallurgy without touching upon the subject of X-ray examination of metals. Examination, as opposed to analysis, is the photographing of metals in order to ascertain if there is any defect in that metal. The principle underlying this method of X-ray work is exactly the same as that employed by the physician when he examines a broken bone by means of X-rays, though the X-ray apparatus used differs very much, in fact, a very similar apparatus to that already described is used, but instead of utilising a discharge of about 60,000 volts, a discharge of generally about 200,000 volts is necessary. It may seem that the transformer required to produce this large voltage is very cumbersome, but this is not the case, and portable units, built on the same lines as the instruments described are in general use.

Perhaps the chief difficulty of this method of examination lies in the fact that only a certain thickness of metal can be examined and, so far as steel is concerned, the limit is about $4\frac{3}{4}$ in. Nevertheless up to this thickness, the results obtained are very useful and important. If a beam of X-rays is passed through a piece of steel, a certain percentage of the radiation is absorbed, but the remainder passes right through, assuming the thickness is not too great. If the steel is entirely homogeneous, and contains no flaws or cracks, etc., there will be absolutely no mark upon the exposed film placed on the other side of the metal opposite to the beam of radiation. If, however, there is a blow-hole in the steel, obviously this will have allowed the radiation to pass through without being interrupted, and in this point, or opposite to it, on the film will be a black over-exposed spot. If, on the other hand, there is inclusion in the steel, which is of greater density than the metal itself, the radiation will have been prevented from passing through to as great an extent as it has done through the steel, which will result in a lighter patch on the developed film, proving the presence of inclusion or other defect.

This type of examination is particularly useful, and is being used to a large extent in connection with welded work, and is very largely overcoming the difficulties that have been experienced by welders in ascertaining if a long run of weld on, say, a boiler barrel or a girder is sound throughout its length.

In conclusion, it is hoped that this short series of articles has increased the interest in X-ray analysis and X-ray work generally. It cannot be stressed sufficiently that although admittedly a difficult subject to those who have never delved into it, it is becoming much less difficult, because the theories underlying the science of X-radiation, and the theories which it so aptly illustrates—that is phase laws and such—are becoming year by year part of the training of the rising generation of metallurgists, and there is no doubt, in the author's mind at least, that before very long, X-ray analysis will be looked upon as essential in the well-equipped laboratory as the microscope is now.

Paris Meeting of the Institute of Metals

Remarkable enthusiasm prevailed at this meeting—the first to be held in Paris—and much credit is due to the painstaking work of the local Reception Committee for the success achieved.

FOR nearly thirty years the Institute of Metals has borne the torch of metallurgical knowledge from one great industrial district to another to illuminate the centres chosen for its autumn meetings. Lit first in Birmingham, it passed to Manchester, Glasgow, Newcastle-on-Tyne, and London. Then—in the year before the war—came the first opportunity to prove that the flourishing young Institute had wider fields to conquer than those of England, so a highly successful inaugural foreign meeting was held in Belgium, in connection with the Ghent International Exhibition. After the war Sheffield was the first host of the Institute—in 1919—and thence onwards, year by year, the great cities of Britain and of the Continent have vied with each other in providing facilities for the metallurgists of this country and overseas to discuss their common problems in a congenial atmosphere.

Though many Continental countries have been the scene of memorable autumn meetings of the Institute for over a quarter of a century it is passing strange that our nearest overseas neighbour has never had a sight of its members—except when they were passing through France *en route* for Germany, Switzerland, or other more distant European meeting place. One can only assume that France is not "institution minded"; certain it is that no body—of technicians or individuals—has ever invited the Institute to France. Putting aside such great institutions as the Société d'Encouragement à l'Industrie Nationale and the Société des Ingénieurs Civils de France—of which the activities are very general and which have rendered great service to metallurgy—there does not exist in France (except the Association Technique de Fonderie and the Société des Ingénieurs Soudeurs) any technical group specialising in metallurgical considerations. Only last month a French technical journal was lamenting the fact that France had nothing to compare with the Institute of Metals and the Iron and Steel Institute—"a gap that should be filled."

This week the Institute of Metals came to France and showed its French admirers something of its activities. The visit was made possible by the kindness and generosity of a group of metallurgical companies, and with the cordial co-operation of the Chambre Syndicale des Métaux—there being no "parallel" society to issue an invitation. The Bureau International des Applications de l'Aluminium was the organising centre of the meeting, its very able Secrerary, Monsieur J. Douchement, acting as Honorary Secretary of the Local Reception Committee and working in the closest co-operation (sometimes with daily visits by air) with the Secretary of the Institute, Mr. G. Shaw Scott, in London. Presided over by Monsieur J. Dalmais, the committee included such well-known French metallurgists as Professors Chevenard, Guillet and Portevin. It planned a splendid five days of instruction and entertainment—now drawing to a close.

With an attendance of over two hundred members from a dozen countries and hundreds of interested visitors, the meeting began in Paris on Monday evening with the Autumn Lecture. Intended as these lectures are—like the opening meeting of the British Association—for the special benefit of people in the district rather than for the members, this year's discourse was given in French by Professor Chevenbard (who holds the distinction of being the Corresponding Member to the Council for France) on a subject that might at first sight appear to be somewhat

Mr. W. R. Barclay, President of the Institute of Metals

outside the scope of the occupant of a metallurgical chair: "The Scientific Organisation of Works." But the Professor soon proved to his hearers that he was a master of his subject, as of the many branches of metallurgy that come within his more immediate province. Quoting Fayol, who held that there are always to be found six groups of essential operations in every enterprise, he showed that, in the growing complexity and difficulty of the processes of certain industries, and in particular of the metallurgy of special alloys, it had become necessary to take into account a seventh factor derived from the first (or technical function), *viz.*, the scientific function. Defining the objective of science in an industrial enterprise to be "to maintain and to improve," the Professor was well on the way to build up his argument for the need of foresight, organisation, command and co-ordination, and control in the scientific planning of factories. As for the control of the unity of the scientific function the lecturer insisted particularly on the minute precautions that are necessary to prevent the slow deviation of the technique of tests and the methods of control from the standard procedure. In conclusion he emphasised the "solemn yet deep satisfaction" that is the reward of the research staff, quoting Lord Kelvin's words: "In the pursuit of truth the work is its own reward and allows the scientist to accomplish with joy his daily task."

Mr. W. R. Barclay, the Institute's President, was happy in his choice of words in conveying to Professor Chevenard the grateful thanks of the large gathering—held in the very modern Grande Salle of the Maisou de la Chimie—for his illuminating and stimulating address, as also was Dr. J. L. Haughton, a Member of Council, who had the ear of the meeting by speaking in French.

Following the Lecture—and in accordance with an appreciated custom set in England on the occasion of similar discourses in previous years—the members and visitors adjourned for an informal gathering and light refreshments. They thus had the first opportunity since their arrival in Paris earlier in the day from all over Europe—and even from Australia and the United States—of that "getting together" which is one of the most useful features of these Autumn Meetings. Later the metallurgical atmosphere of the gathering became accentuated by means of two exceedingly fine sound films—"La Magie du Fer Blanc" and "Quelques pages sur l'industrie française de l'Aluminium." The French flair for cinematography as applied to technical processes is nowhere better exemplified than in the first film in which the manufacture and manifold uses of tinned sheet are made abundantly clear—even appropriate music being used to suggest the regimentation of the sardines as they are being tightly packed in their metal boxes—after the guillotine had done its necessary work—to the tune of the Marseillaise! Scenes of natural beauty, as well as of great technical interest were enjoyed in the aluminium film that concluded a delightful evening's entertainment shortly before midnight.

Next morning saw a more businesslike air come over the proceedings. The informal doings of the night before contrasted with the official welcome which was extended to the assembled members by M. Dalmais, President of the Local Reception Committee and the representative of the Chambre Syndicale des Métaux. Replies to these speeches were made by Mr. Barclay and by Dr. Richard Seligman, a past-President of the Institute, who spoke in French. After the President had welcomed the strong representation of members from many different countries, the first item of serious business was done—the nomination of officers for 1937–38. The members specially cheered the re-nomination for the presidency of Mr. W. R. Barclay, whose present period of office has been marked by many valuable new developments in the Institute's activities.

Turning next to the consideration of the papers—the *fons et origo* of the meeting—included in the programme, the President reminded the members that, for the first time, they had in their hands a booklet (compiled by the Institute and printed in London) containing summaries in English, French and German of each of the nine papers "down" for discussion, as well as a similar—but fuller—polyglot account of the previous night's Autumn Lecture. Because of the existence of these summaries, and of the fact that all the papers had already been printed *in extenso* during the past few months in the Institute's *Monthly Journal*, authors presented their papers only in abstract (sometimes with the help of lantern slides) thus increasing the time available for the discussions—one of the most valuable features of these meetings. The discussion of nine papers continued throughout the mornings of Tuesday and Wednesday. Though aluminium was the theme of a majority of the communications, other metals—notably tin and platinum—and their properties received considerable attention both by authors and members who were anxious to discuss the problems raised. The business sessions concluded with an omnibus vote of thanks to all those to whom the Institute was indebted for the success of its first meeting on French soil.

The time not spent in the lecture hall was devoted to visits that the members were privileged to pay to works in the neighbourhood of Paris (special entertainments being arranged for the ladies) and to gatherings of a social character—luncheons, a banquet, a civic reception at the Hotel de Ville by the Municipal Council of Paris and a dance in the Bois de Boulogne—the two final days of the stay in France being devoted to excursions to Versailles, Rouen and Havre. In the latter town a visit was arranged to the works of the Tréfileries et Laminoirs du Havre.

So concluded one of the most memorable meetings ever held by the Institute of Metals. It could not have been the success it was but for the painstaking work and generosity of the Local Reception Committee, which presented to each member taking part in the meeting, two souvenirs that will long be treasured—a beautiful badge, as artistic as Paris could make it, and a booklet that, though prepared in Paris, was printed in faultless English and included much interesting historical matter and a map showing the points of special interest to the visitors. One wonders, if a similar gathering of a foreign scientific society were held in England, whether we should rise equally to the occasion and place in the hands of our guests a souvenir brochure printed in their own language. The time is certainly coming when we should have the opportunity of seeing what we can do in this connection, for up to now among metallurgical societies at any rate—it seems to be a case of "one-way traffic"—from England to abroad. A hearty welcome would await metallurgists of French, German or other nationality who decided to honour us by visiting England, thus permitting us to repay in as full measure as possible the kindness and hospitality that for so many years have been accorded by our technical colleagues overseas.

TECHNICAL SESSIONS

The Creep of Tin and Tin Alloys—Part I

In this paper Professor D. Hanson and Mr. E. J. Sandford describe the results of the first part of a systematic investigation of the creep properties of tin and its alloys. In previous investigations under this heading quick tests have been used, and since these seemed to be inadequate, the authors have attempted to adopt an endurance period of the order of one year. All the tests described were carried out at room temperature on rolled material. The list of alloys investigated, their identification numbers, tensile strength, and elongation (rate of testing 0·4 in. per inch per minute), and heat-treatment, if any, are given in Table I.

TABLE I.—TENSILE PROPERTIES OF ALLOYS INVESTIGATED.

Composition. %	Reference No.	Ultimate Tensile Strength, Lb./in.²	Elongation, % on 2 in.	Heat-treatment.
Tin	—	2,370	96	Self-annealed†
Silver, 0·1....	A1	2,600	87	,,
0·02...	A2	2,710	89	,,
0·04...	A4	2,760	94	,,
0·1....	A10	2,960	90	,,
3·5....	A350	8,140	—	,,
Bismuth, 1 ...	BI1	5,350	75	,,
2 ...	BI2	—	—	,,
3 ...	BI3	8,870	49	,,
5 ...	BI5	10,390	56	,,
Antimony, 1..	SB1	3,340	57	,,
5	SB5	6,790	68	,,
8·5	SB8·5	10,300	63	,,
10..	SB10	9,210	61	,,
Cadmium, 1 ..	CD1(QT)	5,820	48	Quenched and tempered*
4 ..	CD4(QT)	8,360	38	,, ,,
6 ..	CD6(QT)	9,270	29	,, ,,
6 ..	CD6(SA)	4,700	—	Self-annealed†
33 ..	CD33	11,270	45	,,
Lead, 40	P40	7,660	63	,,
50	P50	6,810	88	,,
60	P60	6,270	88	,,
Cadmium, 33 .	CD33	8,870	198	Tested at 0·1 in./in./min.

The results are given as graphs obtained by plotting the initial stress in lb./in.² against the time, in days, taken to fracture. The results of many other tests under lower loads, in which fracture did not occur, and which, therefore, do not lend themselves to graphical treatment, are incorporated in tables, which also include information concerning the extensions of the specimens. Typical time-extension curves for various alloys are also given, together with illustrations of the types of fracture obtained. The

† For at least 1 month, after which no further softening takes place.
* 1 day at 168° C., quenched: tempered for 1 day at 120° C.
Rate of testing 0·4 in. per in. per min., except where otherwise stated.

results are sufficient to show that short-time tests may, in many cases, give a false impression. This is shown by a comparison of the bismuth-tin and silver-tin alloys; the former have a life many times that of the latter at 1,000 lb./in.², but are considerably poorer at 150 lb./in.².

Several pairs of results for alloys of opposite tensile and creep properties are given in Table VIII., which are sufficient to show that there is no relation between tensile strength and creep properties of alloys of different constituent metals, nor is there always any relation between those of the same constituents; the results of the bismuth-tin alloys show this. It seems, therefore, that long-time creep tests are essential for a full understanding of the behaviour of these metals under prolonged loading. No limiting creep stress was found for any alloy, and in most instances tests carried out from 200 to 300 days are required to enable any estimate, even approximate, to be made of the creep characteristics of the alloys. Tests of one year's duration are probably satisfactory for all practical needs, since it is doubtful whether a part of any structure is subjected to the maximum stress for such a long time in the life of the structure.

TABLE VIII.
COMPARISON OF TENSILE STRENGTH AND CREEP PROPERTIES.

Alloy.	Ultimate Tensile Strength, Lb./in.²	Creep Data.
SB1	3,340	5·5% extension in 340 days at 300 lb./in.²
B13	8,870	18·3 ,, ,, 150 ,,
CD1(Q.T.)	5,820	Life of 434 days at 1,000 lb./in.²
B15	10,390	,, 443 ,, 500 ,,
SB5	6,790	Life of 132 days at 800 lb./in.²
P40	7,660	,, 95 ,, 130 ,,
SB8·5	10,300	Life of 155 days at 1,000 lb./in.²
CD33	11,270	,, 132 ,, 200 ,,

Small additions of silver and antimony improve the creep strength of tin in the self-annealed condition, whilst heat-treated cadmium-tin alloys containing 1–6% cadmium are greatly superior to the self-annealed alloys. To what extent this is due to an increased grain-size, or to constitutional changes is not yet known. Bismuth-tin alloys have a longer life than pure tin at stresses exceeding 300 lb./in.², but they appear to flow more quickly than tin at 150 lb./in.². Lead-tin solder and the 33% cadmium-tin eutectic are particularly weak in the cold-rolled and self-annealed condition.

Metals of the Platinum Group

Ores, Recovery and Refining, Fabrication and Uses, and Properties

The metals which comprise the platinum group are platinum, palladium, iridium, rhodium, osmium, and ruthenium, and a brief description of the discovery of these metals is presented in this paper by Messrs. R. H. Atkinson and A. R. Raper; an account of the ores is also given, and particular attention is devoted to the recovery and refining of the metals produced from the Canadian nickel industry. The authors give a full description of the methods of fabrication of these metals and their alloys, and show that the two ductile metals of the group platinum and palladium are readily worked, while rhodium and iridium are worked with much greater difficulty. The two metals, osmium and ruthenium, belonging to the hexagonal system, have not up to the present been thoroughly investigated. An account is given of the properties of the metals and their uses; the physical properties being reproduced in the accompanying table. (Table II).

A Note on the Influence of Salt Bath Heat-treatment on the Corrosion Resistance of Duralumin Sheet

In view of the extensive use of salt baths in the commercial heat-treatment of duralumin, Messrs. A. J. Sidery and B. Evans have investigated the influence of this method of heat-treatment on the corrosion resistance of the material as compared with that of heat-treatment in air at the same temperature, the results from which are given in this paper. Two series of tests were made. For the first series samples of duralumin were heat-treated at 490° C. in pure sodium nitrate, in salt mixtures, and in salts supplied and used by a number of aircraft contractors. The heat-treatment was followed by quenching in cold water or, in some cases, in cold dilute solutions of the salts employed in heat-treatment. These variously heat-treated samples were then subjected to immersion tests and to intermittent sea-water spray tests for appropriate periods. The corrosion resistance was investigated by visual and microscopical observations and also by mechanical tests. In the second series of tests the authors examined the corroding effect

TABLE II.—PHYSICAL PROPERTIES OF THE METALS OF THE PLATINUM GROUP.

Property.	Platinum.	Iridium.	Osmium.	Palladium.	Rhodium.	Ruthenium.	Units.
Atomic number	78	77	76	46	45	44	
Atomic weight	195·23	193·1	191·5	106·7	102·91	101·7	O = 16
Specific gravity	21·40	22·42	22·48	12·16	12·41	12·20	Grms. per c.c. at 20° C.
Melting point	1773·5° ± 1°	2454° ± 3°	Higher than ruthenium	1553° ± 2°	1966° ± 3°	Higher than iridium	° C.
Boiling point	4300°	>4800°	>5300°	2200°	>2500°	>2700°	° C.
Specific heat:							
0° C.	0·0316	—	—	0·0584	—	—	Calories per grm.
0°–100° C.	0·0319	0·032	0·031	0·0590	0·058	0·061	
Temperature coefficient of linear expansion:							
20° C.	8·9	6·5	—	11·7	—	—	× 10⁻⁶ per ° C.
40° C.	8·99	—	6·6	—	8·5	9·6	
Thermal conductivity: 18° C.	0·166	0·141	—	0·168	0·210	—	Calories cm.⁻¹ sec.⁻¹ temp.⁻¹
Specific resistance, annealed: 0° C.	9·97	5·33	9·5	10·78	4·3	14·47	ohm-cm. × 10⁻⁶
Temperature coefficient of resistance:							
Hard	0·003917	—	—	0·0037	—	—	0°–100° C. per ° C.
Annealed	0·003923	—	—	—	0·00457	—	
Young's modulus	16·8	51·5	—	11·3	27·5	—	Dynes per sq. cm. × 10¹¹
Structure type	Face-centred cubic	Face-centred cubic	Hexagonal close-packed	Face-centred cubic	Face-centred cubic	Hexagonal close-packed	
Unit cell:							
a_0	3·9158	3·8312	2·7304	3·8824	3·7957	2·6987	Angstrom units
c_0/a_0	—	—	1·5785	—	—	1·5833	

of adhering salt from the heat-treatment bath during subsequent storage of the material.

The materials used in the experiments consisted of 20 and 15 S.W.G. duralumin sheets, the analyses of which are given in Table I.

TABLE I.

	20 S.W.G. %	15 S.W.G. %
Copper	4·46	4·47
Silicon	0·28	0·24
Manganese	0·62	0·63
Iron	0·47	0·56
Magnesium	0·55	0·44
Aluminium	remainder	remainder

Water-line immersion tests indicated that the mode of heat-treatment and/or the quenching medium employed had not introduced any variation in either the nature or degree of attack. Negligible traces of intercrystalline corrosion were observed on a few samples immersed in the acidified sodium chloride reagent. No attack of this nature occurred on immersion in sea-water. A considerable amount of superficial pitting developed on all the test-pieces. This was, of course, very much more severe in the acidified sodium chloride solution than in normal sea-water.

The mechanical test results obtained on the series subjected to the sea-water spray test did not reveal any marked margin of variation, and there was no evidence of any unfavourable influence arising from the use of any one salt or salt mixture, as compared with material heat-treated in an electric furnace in air.

Incomplete removal of nitrate heat-treatment salt from duralumin sheets after quenching resulted in the development of surface pitting when the latter material was subsequently stored. There was, however, no tendency towards intercrystalline corrosion of the material under these conditions. Apart from the tendency of salt residues present as a result of inadequate washing to cause superficial corrosion on subsequent storage, such residues are objectionable on surfaces to be enamelled or varnished without prior anodic treatment.

Veining and Sub-Boundary Structures in Metals

Veining structures has been considered in the past mostly in connection with fairly pure irons or low-carbon steels. The investigation of veining structures, described in this paper by Dr. L. Northcott, is concerned with non-ferrous metals and alloys generally. As a result of this investigation veining has been shown to be developed in several pure metals and alloys as a result of slow cooling after the metal or alloy has undergone an oxidising treatment, either by deliberately oxidising the melt or by annealing the solid at a high temperature in air or in the presence of its oxide. Conversely, treating the liquid metal with hydrogen or annealing the solid metal at high temperature for a sufficient length of time in an atmosphere of hydrogen results in a material free from veining,* although veining has been observed under similar conditions of treatment when an oxidising atmosphere has been employed. This type of veining is intimately associated, therefore, with the oxygen or oxide content of the material. Secondly, microscopical examination of the veins at a sufficiently high magnification shows that the veining lines are discontinuous and appear to be made up of a series of small particles of a constituent, which, from the previous conclusion, must consist of an oxide of the metal concerned. Thirdly, since severe quenching from a temperature slightly below the melting point prevents the formation of veining, whereas slow cooling develops it, the solubility of the veining constituent in the metal is evidently greater at elevated than at atmospheric temperatures.

The remaining results—namely, (*a*) the effects of low-temperature recrystallisation where the veining is left undisturbed by the formation of new crystals (or the growth of the original crystals) at temperatures below the solution temperature of the veining constituent; (*b*) the formation of a fresh system of veining with the recrystallisation and growth of new crystals during the high-temperature annealing after cold-work; (*c*) the ability to differentiate between veining and strain-lines after cold-work; (*d*) the action of a powerful deoxidising agent such as phosphorus in reducing or even eliminating veining; (*e*) the effect of the form in which the veining constituent is present on the hardness of the metal; (*f*) the coalescence of the particles during long annealing at intermediate temperatures; and (*g*) the effect of work in aiding the solution of the veining constituent at intermediate temperatures; these results are all consistent with the view that veining is due to the presence of metallic oxides whose solubility in the metal increases with increase in temperature.

One of the results shown by the present work is that many metals dissolve, especially at high temperatures, small quantities of their own oxides. The action is not limited to pure metals, but also occurs with many alloys. Further, although the addition of a deoxidising agent changes the composition of the oxide, it does not necessarily completely remove the oxide from the alloy. The beneficial influence of deoxidising agents, therefore, depends on the properties of the oxide formed, and particularly of that in excess of the quantity which can exist in solid solution. It is also evident, from the small quantity of the veining constituent present and from the chemical purity of the metal even when much veining is shown, that the quantitative solubility is very small indeed.

It is of interest to consider the position of veining structures relative to twinning. Twinning may be classed either as stress twinning, which is due to release of stress at atmospheric or moderate temperatures, or annealing twinning, which, although also associated with stress, does not develop until the temperature is increased sufficiently to permit recrystallisation and, commonly, grain-growth. In the case of stress twinning, the veining, as would be expected, passes through the twinned crystals unchanged. On the other hand, twin crystals formed by annealing at high temperatures were observed more often than not to have their own system of veining, although examples were observed where a vein crossed the twin plane. A study of the relationship between veining and twins would probably yield some information as to the temperature of twin formation and growth.

The results of the present investigation confirm those of the previous investigation on veining in iron,[1] in which it was concluded that veining was due to the precipitation of iron oxide during cooling, and that the solid solubility of the oxide in iron decreases with decrease in temperature. The results also explain the irregularities found in single crystals of copper by W. H. George,[2] who stated that the appearance of the structure (the same as that described in the present paper) suggested that the crystal had broken down into a large number of small ones.

It may be inquired why it is that although the majority of alloy systems contain one or more phase boundaries representing a decreased solubility of a constituent with decrease in temperature, sub-boundary structures are not more frequently observed. There are probably two reasons for this. First, it appears to be necessary to have only a certain small critical amount of the sub-boundary constituent. If much more is present there is too strong a tendency towards either a fine shower precipitate or else a massive one where the constituent is deposited on the initial particles as mentioned previously. Secondly, the rate of cooling is of some importance. In the present work, network structures have been most prominent when cooling has been slow, although an excessively slow cooling may result in too much coalescence to show any network. The optimum cooling rates differ for the different alloys, and

*One exception to this action is given by aluminium as mentioned in the paper. The temperature of the experiment was well below the temperature above which Al_2O_3 is reduced by hydrogen. No reducing experiments were made with magnesium, which is known to form a chemical compound with hydrogen.

1 L. Northcott, *J. Iron Steel Inst.*, 1932, 126, 267.
2 W. H. George, *Nature*, 1935, 136, 392.

it has been shown that whereas furnace cooling which corresponds to a rate of from 6° to 2° C. per minute is satisfactory for many alloys, others, such as the β-brass and beryllium-copper, require to be air-cooled at as high a rate as 300°–100° C. per minute in order to prevent coalescence.

Although the conditions favouring the precipitation of oxides or other compounds in a network form have been considered, no reason has been adduced as to *why* the deposits should assume a network form.

Mechanical Properties of Aluminium and its Alloys after prolonged Heating

This paper, by Prof. Dr. Ing. A. von Zeerleder and Dr. Ing. R. Irmann, describes extensive investigations on pure aluminium and some of its alloys after heating for long periods at 75°–300° C.—a range of special importance to the engineer. The various materials, which included pure aluminium, Peraluman 2, Anticorodal B, Avional D, " Y " alloy, and " R.R. 59 " alloy—after heating at 75°, 100°, 130°, 160°, 200°, 250°, and 300° C. for periods up to two years, showed different behaviour according to their previous treatment and composition.

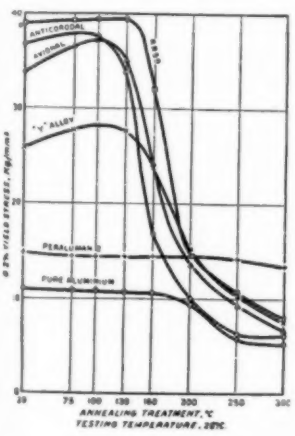


Fig. 28.—Influence of Continuous Heating for one year at temperatures up to 300° C. on the yield-point of pure aluminium and aluminium alloys. Tested at 20° C.

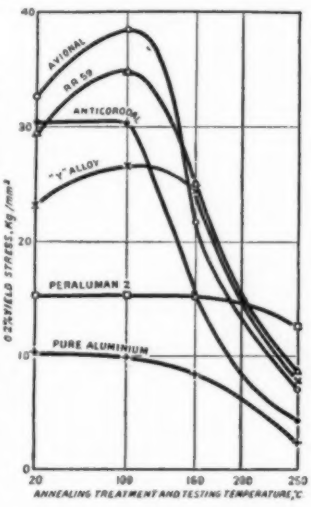


Fig. 29.—Influence of Continuous Heating for one year at temperatures up to 250° C. on the yield-point of pure aluminium and aluminium alloys. Tested at the annealing temperature.

After treatments of different duration at elevated temperatures, some specimens were cooled and tested at room temperature; others were tested at the treatment temperature. The authors collected the results of their investigations, carried through with different alloys in Fig. 28, showing the influence of annealing at different temperatures between 75° and 300° C. and the testing results at 20° C. on the yield-points. On Fig. 29 the yield-point tested at annealing temperature is represented. The curves for Avional and " Y " alloy show a marked increase in yield-point (room temperature) after heating to temperatures up to 100° C. " R.R. 59 " is distinctly superior to Avional and " Y " alloy after heating at temperatures up to 160° C. On the other hand, the yield-point of the copper-free alloy Anticorodal decreases very rapidly after 100° C., and at 160° C. is already much lower than that of alloy Avional, " Y " alloy, and especially " R.R. 59." After heating at 200° C. the yield-point of Anticorodal is even lower than that of the alloy Peraluman 2, and nearly as low as that of pure aluminium. Further, it can be seen that even at 160° C. " R.R. 59 " is distinctly superior to " Y " alloy and Avional.

Pure, half-hard aluminium is not affected appreciably up to 160° C. For 300° C. the differences between the alloys become very small; only Peraluman 2, which is used in the soft state and is not heat-treatable, forms an exception, as would be expected. Even after heating at 300° C. it shows no substantial decrease in strength and has a higher strength than all the other alloys.

Almost the same observation is obtained from an examination of the temperature of heating on the yield-point of the alloys heated for one year at 100°, 160°, and 250° C. and tested at these temperatures. " R.R. 59 " is found to be distinctly superior up to 160° C. It will be noted that the 0·2% yield-point of " R.R. 59 " still increases up to 100° C. This suggests that the precipitation-hardening of the original material was incomplete.

These investigations have shown that it would not be permissible to take as final strength after prolonged heating at a given temperature the results of tests of fully stabilised material tested at room temperature or at the temperature of heating after being heated to the temperature concerned. It appears to be necessary to carry out the lengthy procedure of prolonged heating tests for each alloy.

The curves included in the present paper give the strength of pure aluminium and of some wrought aluminium alloys after prolonged heating. Results of this kind are often required by engineers, and the yield-point is of service as a basis for calculation. The yield-point observed in the normal tensile test (0·2% permanent extension), however, does not represent the strength for 0·2% permanent strain under loading of long duration. The matter of permissible stress under prolonged loading is one relating to the so-called " creep-limit " at different temperatures, which, as indicated by results obtained to date, sometimes lies much below the 0·2% yield of the normal tensile test.

The Complex Interdependence of the Properties of Alloys and the Industrial Conditions of their Manufacture, Testing and Use.

All metallurgists in contact with manufacture are aware of the many apparently unrelated factors which are brought to light during experiments with new alloys, new processes, or new tests. In addition to the problems involved in the pursuit of improved properties, in meeting more rigid tests, in the perfecting of manufacturing technique, or imposed by the design and dimensions of the article, either in the foundry or in use, there are the more general but less evident troubles which intervene unexpectedly, in a manner at once more deceiving to the founder and more dangerous to the user, since they are difficult to trace and are often aggravated by apparently logical remedies. In the interpretation of an incident of either fabrication or functioning, both direct and indirect factors should be considered; better still, they should be foreseen by the management from a continual analysis of the facts of production. In this paper the Marquis R. de Fleury and Dr. H. Portier direct attention to the unsuspected and troublesome factors which intervene at every stage between the production and utilisation of an alloy.

The indirect factors influencing the properties of light alloys in service are classified, and some methods of recognising and controlling them are described. Some actual examples are given of a number of external factors which, by their subtle and often unsuspected interdependence, have been able to upset the manufacture and functioning of a machine. The authors warn metallurgists against the unconsidered application of new alloys, and engineers against hasty condemnation of the materials with which they are supplied. In spite of careful forethought, metallurgists and engineers will encounter unsuitable applications which will throw a prematurely advertised material into disfavour. This is the explanation of the amazing set-backs to be remembered in the history of the most logical new developments.

The Conductivity of Super-Purity Aluminium : The Influence of Small Metallic Additions

This paper, by M. Gaston G. Gauthier, deals with the effect on the conductivity of super-purity aluminium (exceeding 99·99%) of additions of those elements which may occur as impurities in commercial aluminium. It is shown that aluminium follows the universal law that the conductivity and the temperature co-efficient of conductivity both increase with the purity : Mathiessen's law has been confirmed. The data presented on the effect of small additions on the conductivity of aluminium are of value in that they have been determined under favourable experimental conditions, owing to the extreme purity of the basis metal and the large amount which has been available. This high purity has made it possible to determine, with a stated accuracy, the effect of each one of the added elements in the almost complete absence of other impurities. Further, the figures given for iron and silicon, for these elements with titanium and vanadium, and for magnesium and silicon, make it possible to calculate the conductivity of aluminium of accurately known purity.

The average decrease of conductivity brought about by the different elements within the limits investigated are

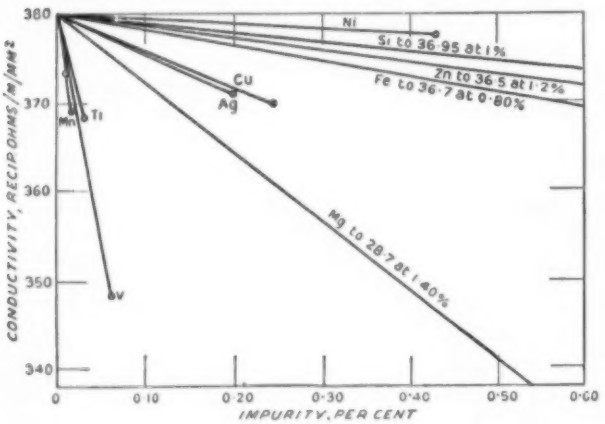


Fig. 4.—Mean decrease of conductivity in alloys of aluminium as a function of the content of alloying element added.

shown in Fig. 4, from which it will be noted that it is possible to divide the elements into three groups :—

(1) Gold, gallium, nickel, silicon, iron, and zinc, all of which have little effect.
(2) Copper, silver, and magnesium, which have rather more effect.
(3) Titanium, vanadium, manganese, and chromium, all of which exert a considerable effect.

The author states that it has only been possible in certain instances to compare the results with published data, largely because the present work has been based on aluminium of particularly high purity, thus eliminating the complications due to the interaction between added elements and incidental impurities. It should be added that certain differences, incompletely explained, may be due to variation in the mechanical or thermal treatment as used by the present author and by other investigators. It is pointed out that Norbury's law does not appear to hold good for aluminium.

An Anodic Treatment for the Production of Aluminium Reflectors

This paper by Mr. N. D. Pullen is concerned with an electrochemical method for the production of aluminium surfaces having a high reflectivity value when measured in the normal manner, using daylight or an artificial light as source of illumination. The surfaces were treated by a dual anodic process. The first bath in which the electrolytic brightening is produced is a mixture of sodium carbonate and sodium phosphate in the approximate proportions of 3 : 1, having a strongly alkaline reaction. The second bath, in which a reinforcing film is produced, consists preferably of a strong solution of acid sodium sulphate.

The reflectivity values for aluminium of 99·8% purity treated by this process are given in Table II. and compared with similar values for nickel, silver, and chromium plate, and other materials generally used for mirrors or reflectors. The silver, nickel, and chromium specimens were in the form of plated brass sheet as supplied by manufacturers for reflectors. Each specimen was flat and highly polished. The aluminium specimen was a piece of commercial sheet, also polished and electrolytically brightened. The measurements were made in an apparatus using a photoelectric cell, and since the conditions of each experiment were identical, the results are comparable. The figures represent the percentage of incident light reaching the cell after reflection by the metal surface compared with a standard silvered mirror taken as 100.

Although the experimental work described was carried out using pure aluminium sheet, the reaction of a certain number of alloys was also investigated. In a certain number of cases the results were disappointing, but a few alloys have been found with which the results were quite successful. The operation of the process on a scale considerably larger than is possible in a laboratory has already been tested, and few difficulties were experienced.

Study of the Forgeability of Various Light and Ultra-Light Alloys

In this paper Prof. Albert Portevin and Dr. Paul G. Bastien have endeavoured to determine, by means of laboratory tests, the optimum conditions for hot-working light and ultra-light alloys. With this in view, they have compared the results obtained from static bending and compression tests and dynamic bending and tensile tests. They have indicated the important part played by the rate of deformation, and have shown that the bending test appears to be the most convenient, speedy, and sensitive. The tests have been carried out on aluminium ; on copper-aluminium alloys, containing 6 to 12% copper ; on aluminium-magnesium alloys containing 5, 10, and 15% of magnesium ; on magnesium ; on magnesium-copper alloys containing 5, 10, and 15% of copper ; and on magnesium-aluminium alloys containing 3, 6, and 9% of aluminium. The methods of testing employed have made it possible to define the capacity for hot-work of these various alloys.

As a result of this study, the authors have arrived at the following conclusions, which apply to all the alloys considered :—

Static Bending Tests.—In every case, resistance to static bending passes through a more or less spread-out maximum between 100° and 200° C. The bend at the moment of

(*Continued on page* 148)

TABLE II.

Standard Mirror.	Aluminium Mirror.*	Brightened Aluminium.	Stainless Steel.	Silver Plate.	Nickel Plate.	Chrome Plate.	Plate Glass Mirrors.	
							Thick Plate Glass.	Thin Plate Glass.
100	101·5	86·0	54·0	97·0	72·0	72·0	91·5	95·0

* Distilled aluminium on glass.

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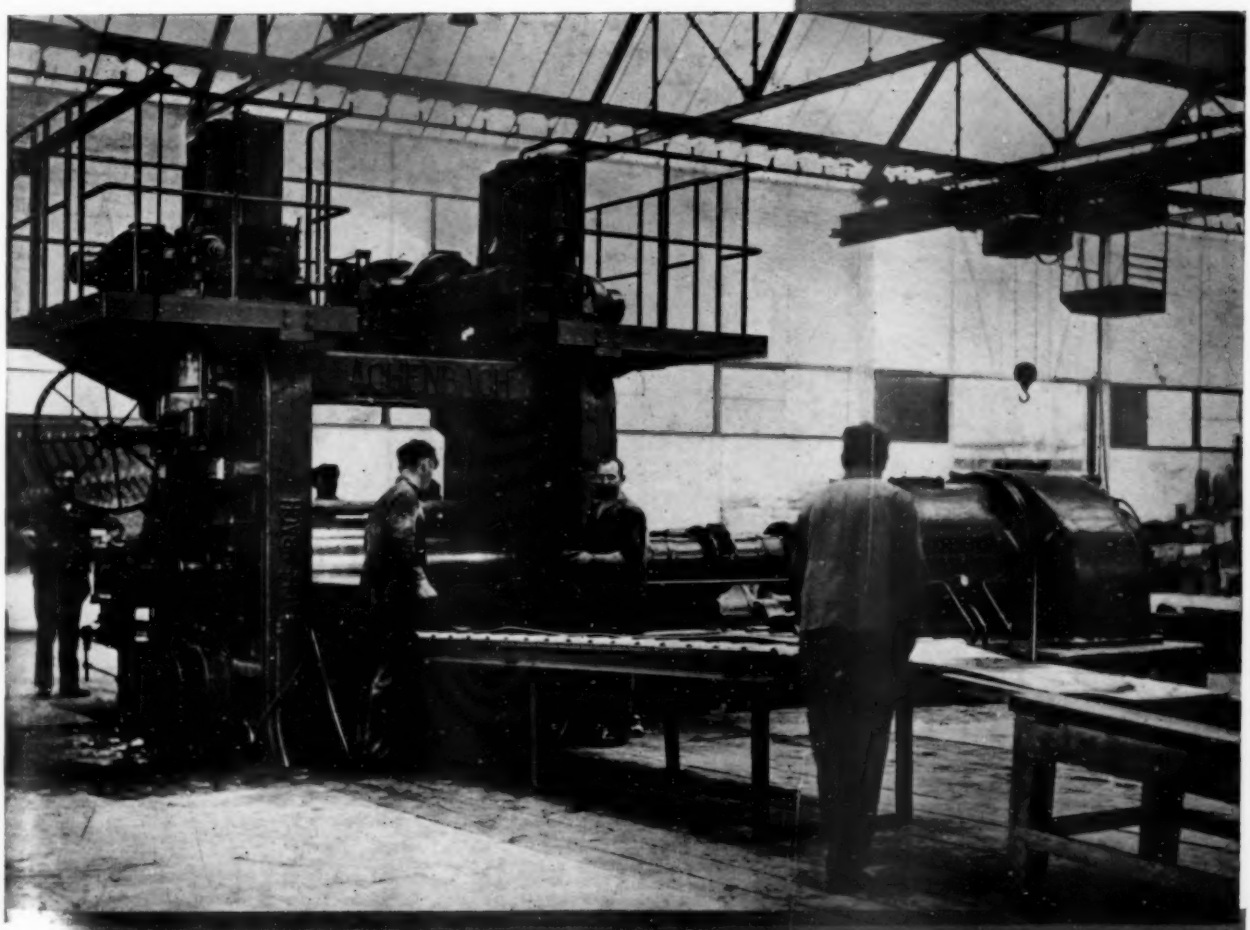

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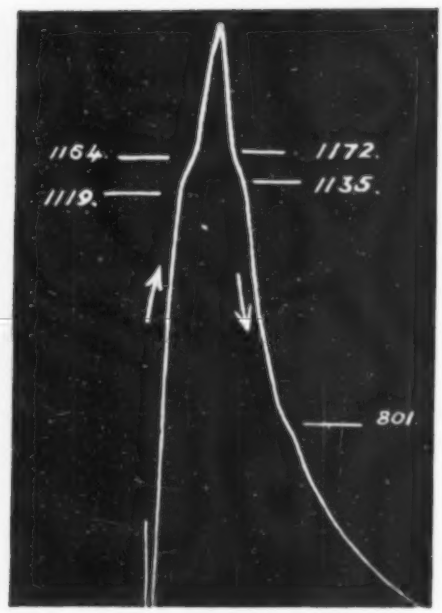

REFINED CHROMIUM ALLOY PIG IRONS

ONE of the difficulties of ensuring regularity and uniformity of the chromium contents in chromium alloy cast iron arises from the high melting points of chromium and rich ferro-chromes. The melting point of pure chromium itself is high, viz., 1620° C. The ferro-chromium alloys are likewise refractory, and in the high carbon ferro-chromes containing 6 to 8 per cent. carbon, there exist compounds which only melt completely above temperatures of 1600° C. to 1700° C. These temperatures are considerably higher than the freezing point of the eutectic iron carbon alloy, which is 1160° C.

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CHEMICAL COMPOSITION:

Total Carbon	4.00%
Silicon	2.00%
Manganese	0.46%
Sulphur	0.088%
Phosphorus	0.45%
Chromium	7.90%

THERMAL DATA:

Melting Commenced	1119° C.
Melting Finished	1164° C.
Freezing Commenced	1172° C.
Freezing Finished	1135° C.
Recalescence	809° C.

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The Iron and Steel Institute

Autumn Meeting in Düsseldorf

A very extensive programme has been arranged in connection with this meeting in Dusseldorf, which promises to be one of the most interesting meetings to be held by this Institute. A summary of the programme is given, together with a brief reference to the history of the Verein deutscher Eisenhuttenleute. at whose invitation the meeting is being held in Germany,

THE autumn meeting of the Iron and Steel Institute, to be held in Düsseldorf on September 21–26, shows every prospect of success. The arrangements of the meeting are in the hands of an influential and representative committee, whose chairman is the President of the Verein deutscher Eisenhuttenleute, Generaldirektor Dr. Ing., Dr. Ing. E.h. Fritz Springorum, and those members who participate to the fullest possible extent will have a very busy time. Unfortunately, Sir Harold Carpenter, F.R.S., President of the Institute, for reasons of health, has been obliged to cancel his intention to take part in the meeting. However, Mr. James Henderson, J.P., honorary treasurer of the Institute, has been nominated Acting President.

The initial meeting will be held in the Tonhalle, where the members and their ladies will be welcomed by Generaldirektor Dr. Ing., Dr. Ing. E.h. Springorum, by the Oberbürgermeister of Düsseldorf (Dr. H. Wagenführ), and by the members of the Reception Committee. This will be followed by the general business meeting of the members. Several reports and fifteen papers are to be presented at this meeting, but, since the reading and discussion of papers is limited to two morning sessions, only a few of the papers will be presented for oral discussion. Thus, during the morning of September 21, four papers will be presented and discussed if time permits. The following morning a joint meeting with the Verein deutscher Eisenhuttenleute will be held in the Tonhalle, at which four papers are expected to be presented for discussion.

Demag charging plant and ore loading bridge for the Mannesmann-Rohrenwerke, Abt. Heinrich Bierwes Hutte, Duisburg-Huckingen.

On the afternoons of each of these days visits are arranged to works and places of interest in and around the city of Düsseldorf. The whole of the following day, September 23, is devoted to visits to works in the Lower Rhine district, while the two following days are devoted to works visits in the Cologne, Dortmund, and Mülheim districts, and to works at Essen and Dortmund respectively.

Extensions of the programme to include excursions to Saarbrücken, the home of well-known companies engaged in the production and finishing of steel, or to Seigen, with its important roll foundries, machine-construction plants, and sheet works. Very complete arrangements are made for the ladies, which, together with the various functions planned, will make the short stay in Germany one to be remembered.

Verein deutscher Eisenhuttenleute

This meeting is being held in Düsseldorf by the invitation of the Verein deutscher Eisenhuttenleute acting on behalf of the German Iron and Steel Industry. This Association was founded in 1860, when a few metallurgists met and a committee formed to prepare the preliminaries for a new association devoted to metallurgy. In due course the inaugural meting of this Association was held. There was an inclination to join up with the Engineers' Association, and in the year 1861 the linking-up actually took place, but the Association reserved to itself a fairly extensive independence.

For nearly two decades, this relationship continued to exist with the Engineers, until the completely altered situation in the technical and economical conditions revived the desire for the Metallurgy Association to be given back its former independence. Thus, at the General Meeting which took place on November 20, 1880, on the motion of the Managing Committee, it was resolved to break away from the Engineers and to again form an independent association under the title of " Verein deutscher Eisenhüttenleute."

Carl Lueg, Director of the Good Hope Mine in Oberhausen, was elected President of the new Association, and continued to guide its destiny for 26 years until his death in 1905. To commemorate his meritorious service to the Association a medal was struck in 1903, and was called " the Carl Lueg Commemorative Medal. This medal is, as a rule, awarded once a year for services to metallurgy, in the technical and scientific sphere. Upon regaining its independence in the year 1881, the Association made immediate plans for producing its own journal, and these plans grew to a head in such a short time that on July 1, 1881, the first issue of the periodical, *Stahl und Eisen*, was able to appear.

An important event was foreshadowed in 1896, when the hon. member, F. R. Krupp, by means of a donation, made it possible for the Association to acquire its own premises, which, with an adjoining building acquired a few years later, served for the purposes of the management up to 1910. As a result of the co-operation of the iron and steel industry and the city of Düsseldorf, and also the untiring work of Emil Schroder, it became possible to enter larger premises in the summer of 1910. In order to promote

further the work of the Association, branches were established in a number of districts.

In the first decade, it was possible to deal with the questions down for discussion at the general meetings, which, as a rule, took place twice a year. If a matter required prolonged discussion, then "committees" were appointed, and these automatically dissolved after settling the work in hand. In course of time, however, it was found that the progress in the special fields of metallurgy became so rapid that technical questions had to be assigned to special expert committees. These committees of experts, which alone were able to appoint further sub-committees for the treatment of special matters, differ from the former committees, in that the membership is not personal; the members are, for the most part, ironworks, which send their experts to the various meetings.

By about the year 1917, the iron and steel industry had laid the foundation stone of an important task towards the establishment of an institute for free scientific research in the sphere of iron and steel. The preliminary work, which had to provide for financial and organising support for the research premises which were to be founded, was transferred to the Association, and the Institute was finally enrolled under the name of the "Kaiser-Wilhelm Institute for Iron Research," among the number of research institutes of the "Kaiser-Wilhelm Society for the Propagation of Science." The Institute began work in 1918 at Aachen, but recently it moved to new premises in Düsseldorf, built in the years 1934-5. The first director of the Institute, from its foundation until the end of 1922, was Herr Geheimrat, Prof. Dr. F. Wüst, and his successor, the present director, Prof. Dr. F. Körber.

The internal organisation of the Institute is divided into the following scientific departments:—

1. Ore-dressing department.
2. Chemical and analytical department.
3. Physics department.
4. Metallographical department.
5. Metallurgical department.
6. Department of mechanics.
7. Technological department.

In addition, there is a department responsible for internal organisation.

The results of the research work are published in the *Mitteilungen aus dem Kaiser-Wilhelm Institut für Eisenforschung*, and may be obtained through the publishing house of Stahleisen m.b.H., Düsseldorf.

It has only been possible to deal very briefly with the history of this Association, but sufficient has been said to show that Verein deutscher Eisenhüttenleute, after years of useful activity in the service of the German iron and steel industry, is a firmly established structure which has been conscious of the tasks originally set for serving the industry. Although primarily the work done has benefited Germany, contributions to problems presented have assisted in the progress of iron and steel production throughout the world.

Technical Sessions

The papers presented for discussion at this meeting varied considerably, but each deal with some aspect of iron and steel production which has a special significance. Probably one of the most interesting is that presented by Dr. Ing. E.h. Fritz Springorum, who deals with the technical developments in German iron and steel production during the last fifteen years. In this paper it is emphasised that the problem which confronts the German steel manufacturer is not so much increased production, but the raw material situation, and technical developments are grouped under two headings—viz., economic operation and improvement in quality of the finished products. These subjects are too comprehensive to describe in detail in one paper, but the outline of technical developments during the period mentioned demonstrates the basic principles in the progress of German steelworks in a few typical fields.

One economic aspect of steel production is discussed in greater detail by Dr. Ing. Friedrich Wesemann, in a paper on the firing of open-hearth furnaces in German steelworks. The situation in regard to the conservation of fuel which faced German steelworks in the years following the war led to an extension of the fuel basis of open-hearth steelworks in the direction of brown-coal-briquette gas, mixed gas, and pure coke-oven gas. These are discussed in terms of their combustion temperatures, the luminosity of the flames produced, and the input of heat into the furnace. The question of burner and chimney dimensions in relation to the heat requirements of the furnace is considered, as also is the heating surface of the checker-work in the regenerators. The author also discusses the relations between the size of furnace, heat consumption per hour, output, and area of furnace.

Another aspect of heat conservation is presented in a paper by Messrs. W. J. Brooke, H. R. B. Walshaw, and A. W. Lee, which deals with investigations into the influence of coke quality on blast-furnace operations. By means of graphs and tables, the authors show the results that have been observed from various experiments made in different directions. The work is concerned with the Normanby Park Steel Works, Scunthorpe, where a special staff has been employed daily in making very careful tests on all branches of the coke quality when manufactured, and its resultant relationship to the daily working of the furnaces. Investigations have been made into the coking properties of various slacks used, and the results of swelling tests on these slacks are given.

The endeavour to increase the quality of steels and the need for precision in the manufacture of uniform quality involve a thorough study of the methods of production and an accurate knowledge of the influence of elements accompanying the iron on the characteristics of the latter. Systematic investigations have been in progress for some time by the Kaiser-Wilhelm-Institut für Eisenforschung relative to the course of the metallurgical reactions during the making of steel. These investigations necessitated more accurate methods for determining the oxygen, nitrogen, and hydrogen present, and a paper by G. Thanheiser deals with the determination of the gases in steel by the hot-extraction method. The author gives an account of investigations on the hot-extraction method, and by means of a few examples of work done demonstrates the great value of oxygen and hydrogen determinations as an aid to metallurgical research and practical investigations.

In making calculations to fix the dimensions of structural members or machine parts, it is usual to assume that the elastic limit of the material is nowhere exceeded. For several decades theory has occupied itself with the consideration of cyclic strains which are partly plastic, but the method of approach has been very curious. It has been tacitly assumed that the plastic component of strain increases directly as the frequency, without making any experiments to test whether the assumption was justified. The theoretical treatment is greatly simplified by making the assumption that damping forces are directly proportional to the velocity, and the mere fact that it renders calculation easy has sufficed to tempt workers to proceed on the hypothesis that "mechanical hysteresis" or "internal solid friction" varies directly as the speed of deformation.

The practical importance of the damping capacity of metals, especially steels, is discussed in a paper by Prof. Dr. Ing. O. Föppl, who states that damping does not foretell impending fatigue failure, nor does it tend to disappear under prolonged cyclic stressing. On the contrary, it is capable of dissipating an unlimited amount of energy in heat without damage to the material. Ultimate damping—*i.e.*, the steady value attained after some millions of cycles, is often considerably greater than the initial damping. Finally, the author gives attention to the need for a ductile steel which will give high damping at low stresses.

An important contribution to the subject of controlled grain size in steel is presented in a paper by Dr. T. Swinden

(*Continued on page* 146.)

Düsseldorf Meeting Works Visits

The works visits open to members attending the meeting in Düsseldorf present an opportunity of making a brief practical survey of the German iron and steel industry, and to note the developments which have been made to obtain economy in operation with improved quality of products. In this article the works to be visited are briefly summarised.

FROM a technical point of view, visits to works can frequently be as useful to the members of a technical organisation as the presentation of papers, since many aspects of production can be seen at first hand and comments can be made on the spot which enable discerning visitors to draw useful conclusions. This is particularly true of the visits arranged in connection with the Iron and Steel meeting in Düsseldorf, when practically all the German works engaged in the heavy industries will be open for inspection. It is doubtful whether, in general, greater progress has been made in any country than in Germany, For this reason these visits cannot fail to be profitable both to the companies whose works are being visited and to the members who take advantage of the privilege. In the majority of instances the works included in the visits are so large that a general outline of them, such as is given in this article, will be helpful.

View of the Haentrop open-hearth steel plant.

BOCHUMER VEREIN.

IN 1842 a crucible steeworks was founded in Buchum by the firm of Mayer and Kühne. This firm was changed into a joint stock company in 1854 under the title Bochumer Verein fur Bergbau und Gusstahlfabrikation A.-G. one of the partners of this old firm, Jacob Mayer, being the first director. A hard worker, Mayer was largely responsible for the successful beginning of the Bochumer Verein. The production of steel castings from patterns was originated by him, and his invention gave to engineering one of its most important raw materials in the shape of steel castings. This was appreciated in 1855, when, at the Paris World Exhibition, a steel bell cast at Bochumer Verein created much interest among steel experts. The value of steel castings for rolling stock and all forms of railway engineering was quickly recognised, and under the direction of Jacob Mayer and Louis Baare, who was appointed Director-General in 1855, the company rapidly predominated in the field of railway steel manufacture.

Rolling mills and a forge were laid down in 1865, and shortly afterwards Bessemer steel works were built and a rail rolling mill installed. In order to ensure adequate supplies of pig iron and independence from outside sources of supply, the Bochumer Verein acquired ore mines and installed a blast-furnace plant.

To-day the blast-furnace plant comprises four blast-furnaces. They are fully mechanised, and coke is conveyed from a neighbouring colliery—Carolinengluck—by aerial ropeway direct to the furnace-charging platform. The ore is conveyed to the company's canal harbour, from which it is transported over private railway lines to the stock-yard, which, together with the furnace bunkers, is spanned by a gantry 240 ft. wide.

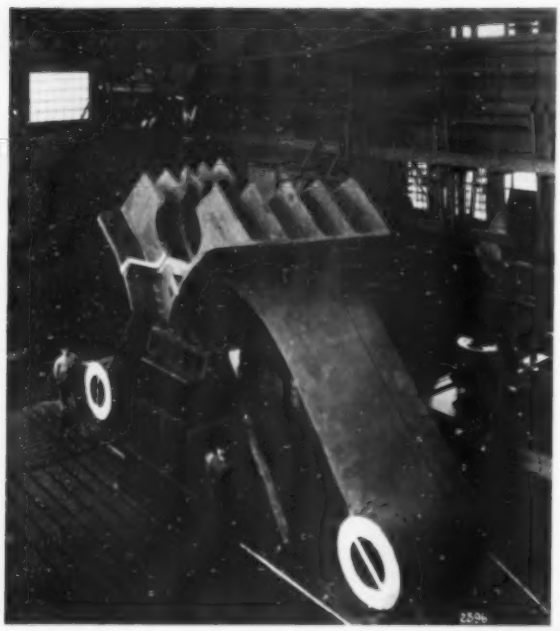
From 40 to 60% of the ore charge consists of sintered material. Purple ores, flue dusts, and ore fines are treated in a sintering plant, designed on the Dwight-Lloyd system, which is recognised as one of the most modern of its kind. The blast-furnace gas is cleaned in a dry purification plant designed on the Halberg system, and is distributed to various parts of the works and used for heating purposes. The product of the blast-furnaces is chiefly forge pig iron, suitable for steel manufacture in open-hearth furnaces. The iron is conveyed, mainly in a molten condition, to the open-hearth furnaces, but to the company's more distant steelworks the pig iron is dispatched by rail. As a rule, the company makes its own requirements of hematite iron or spiegel.

A more recent extension of the Bochumer Verein is the Hoentrop open-hearth plant, built during the years 1921-4, about two miles from the old works. These works are claimed to have the most modern and best-equipped Siemens-Martin plant in Europe. In planning these steelworks, the following features were kept in view :—

(*a*) No solid fuel was to be used.
(*b*) Furnaces were required to produce steel of every description at the lowest possible cost, from either cold or hot metal.
(*c*) Casting pits designed to facilitate the casting of large quantities of ingots of varying dimensions.
(*d*) Transport reduced to lowest limits and provided for on standard trucks.

The building consists of five bays under one roof, 538 ft. long, 425 ft. wide, and 95 ft. high. Four tilting furnaces comprise the melting plant, which are installed in a spacious furnace bay 72 ft. wide. The casting bays each have 90 ft. span, and adjoining is a bay for ingot-dressing. The furnaces are heated by a mixture of blast-furnace and coke-oven gas in the ratio of 2 : 1. Most of the ingots cast at these works are for the production of seamless rolled tubes.

Bochumer Stahlindustrie, which were amalgamated in 1920, is equipped with rolling mills specially designed for rolling high-class steels. Here also strip is cold-rolled for special purposes. The Weitmar rolling mill, plant which consists of five trains of rolls, where railway rails and tramway rails, of ordinary and compound steel quality, special sections for tramway and railway purposes, blooms, billets, slabs, bars, spring steels, fishplates, guide rails, etc., are rolled. This is also the plant at which the patent compound steel rails are manufactured. As in the early days, Bochumer Verein has taken, and is taking, a most active part in the technical development of railway equipment. In 1934 these works supplied the wheel sets for the most modern type of express train locomotives for a speed of about 110 miles. It is noteworthy that the lightweight wheel sets with hollow axles were developed at these

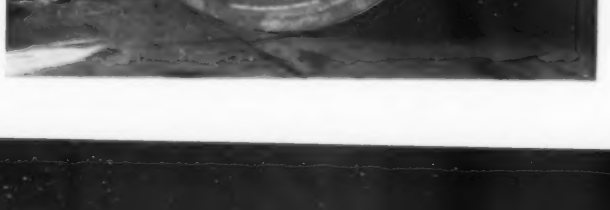


Shaft brackets of the Bremen, cast at the works of the Bochumer Verein.

works some years ago. Their weight is reduced by 25 to 40% of the weight of the standard wheel sets, thus diminishing the hammering effects and securing a saving in wear of track. A modern building, erected on the ground originally occupied by Jacob Mayers' crucible steelworks, now comprises the testing department, which is equipped with the most modern testing machines and machine tools. The research department is housed independently, and has full control of the steel production. Its further duties include investigations with a view to improving steel qualities and the development of new grades.

The education of the young workers is systematically promoted in every way. Every year about 150 boys are enrolled as apprentices. They start working at the works' school for mechanics. During the first three months every boy is put to the lathe, and the following three months are used to acquaint him with fitting. After this period he is able to determine his special aptitude, and for two years he gets special instruction in the apprentices' shop. Later on, the boys pass into the works, where they learn to operate various tools. During the four years' instruction the boys attend continuation classes

Social welfare has always been a feature of the works' management, and a housing scheme for the workers has long been associated with these works, and it will probably be this side of the works' activity, coupled with the remarkable cleanliness of the plant, which will leave the most lasting impression on the visitors.



A Francis turbine runner; a steel casting of 30 tons, made by the Bochumer Verein.

THE DEMAG COMPANY, DUISBURG.

THE company is one of the largest manufacturers of machinery in Europe. It has works in Duisburg, Wetter, Benrath, and Mülheim (Ruhr), and employs over 10,000 workmen. The head offices are at Duisburg. The foundation of this company was laid in 1819, in the heart of the Rhenish-Westphalian industrial area. At the beginning the firm concerned itself with the construction of steam engines, steam hammers, steam boilers, rolling mills, etc.

Demag Duisburg Works I., viewed from the harbour.

While still in its early stages, however, it took up the construction of cranes and transporting plants. After the amalgamation of the Märkische Maschinenfabrik with the firm of Ludwig Stuckenholz, keen competition was experienced in the neighbourhood from the Duisburg Maschinenbau-A.G. and the Benrath Maschinenfabrik A.G. Amicable working agreements were eventually made between these three competitors, which led in 1910 to the complete amalgamation of the three firms under a joint stock company, styled Deutsche Maschinenfabrik A.G., which under the name " Demag " quickly gained a world-wide reputation.

This amalgamation began a period of expansion and development. It led to the affiliation of a number of other firms, which either, like the engineering works of Meyer in Mülheim, Tigler and Jäger, and the bridge-building firm of Harkort in Duisburg, became completely absorbed in the Demag, or those from which certain branches of manufacture were acquired. Amongst other branches of manufacture taken over in this way were the steelworks construction department of the Mitteldeutsche Stahlwerken, Abt. Lauchhammer-Rheinmstall; the construction of steam engines, compressors, and compressed-air locomotives from the Maschinenfabrik Hohenzollern in Düsseldorf, and the construction of rolling mills from the Kalker

Erecting bay for steelworks plants at the Demag Duisburg Works.

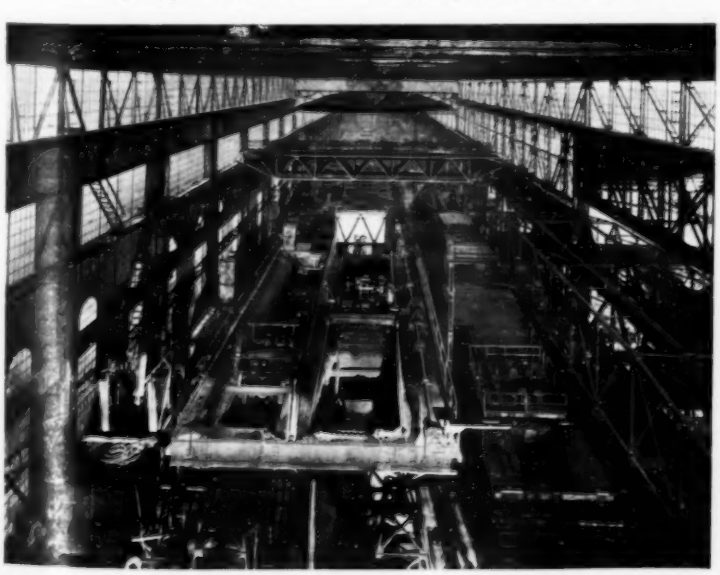
Maschinenfabrik A.G. in Cologne-Kalk, thereby considerably extending and strengthening the already existing departments. In like manner, the manufacturing rights for turbo compressors and large volume piston compressors were acquired conjointly with another company from Frankfurt Maschinenfabrik A.G. In 1926 the new company, styled the Demag Aktiengesellschaft in Duisburg, was formed by the amalgamation of the Deutsche Maschinenfabrik A.G. with the Maschinenfabrik Thyssen and Co. A.G. in Mülheim-Ruhr, belonging to the Vereinigte Stahlwerke A.G.

The field now covered by the activities of this firm is extraordinarily wide, comprising mining machinery, such as hoisting and conveying plant, compressors, compressed-air tools, pneumatic conveyers, etc.; machinery for charging blast-furnaces, machinery for steel works and rolling mills, and the usual auxiliary machines and transport works. It includes shipyard and harbour installations; chemical industry, power stations, public works, railway, transport, and factory service of every kind. Although this firm is in the forefront in several important fields, particularly in respect of iron and steelworks plant, crane construction, etc., it does not confine its activities solely to the construction of the largest machines of this class, but also manufactures them in series, for which special factories are maintained.

Some idea of the size of this firm may be gathered from the fact that the Benrath Works, at which slewing cranes, overhead travelling cranes, loading bridges, and the like, are constructed, cover an area of 313,000 sq. yds. At the Duisburg Works I, where the head offices are located, and where the work embraces steelworks plants, power engines, etc., the works occupy 98,000 sq. yds. A second works in Duisburg, which deals with bridge-building and all kinds of structural steelwork, occupies an area of 60,000 sq. yds. The works at Mülheim-Ruhr cover an area of 122,000 sq. yds., while the Welter-Ruhr works occupy 136,000 sq. yds. All the works are full equipped and include some of the most modern plants and machine tools; indeed, machine tools are installed which can cope with every demand, however large the individual parts, and the large erecting shops permit of the assembly and trial running of even the largest of plants.

Many members of the Iron and Steel Institute will renew their acquaintance with the Duisburg Works, and will note the developments which have taken place in recent years. Some of the machine tools will prove of outstanding interest.

Erecting bay for steelworks cranes at the Demag Works at Welter, Ruhr.



DEUTSCHE EDELSTAHLWERKE, A.G. KREFELD.
(GERMAN REFINED STEEL WORKS.)

THIS firm was formed early in 1927 from the Edelstahl Studien A.G., which comprised the following old-established refined steel works: The Mining Steel Industry, Remsheid; the Bochum Steel Industry, Bochum; the Bell Steel Works, Richard Lindenberg, Remscheid; the Cast Steel Factory, Felix Bischoff, Duisburg; the Krefeld Steel Works, Krefeld; the Dortmund Magnet Factory, Dortmund; the Brunginghaus Steel Works and the Werdohl Steelworks, Haslach. The amalgamation of these works was designed to make better use of the existing plants, to combine their accumulated experience and modern economic production processes with a view to the manufacture of the highest quality of refined steel. In the latter part of 1929, the management and registered office of the company was transferred from Bochum to Krefeld, and this factory was selected as the principal steel base and manufacturing centre.

The company now controls the Krefeld Works; Remscheid Works; Hammerwerk Bruninghaus G.m.b.H., Werdohl; Magnetfabrik, Dortmund; High Frequency Crucible Steel G.m.b.H., Bochum; and Hannover Works. Since the change in the German political outlook, and the development of a scheme of national economy, the position of this company has shown continual improvement, which has made possible the complete reorganisation of the works and of the sales organisation, and enabled the company to compete successfully with alloy steel manufacturers throughout the world.

Some idea of the scope of this enterprise, which employs over 5,000 people, will be gathered from the following: At the Krefeld Works the products include crude ingots, semi-finished, bar steel, rolled, forged, drawn, polished (ground) in all the usual refined steel alloys; sheet-metal: black-rolled, matt-pickled, bright finished, highly ground and polished;

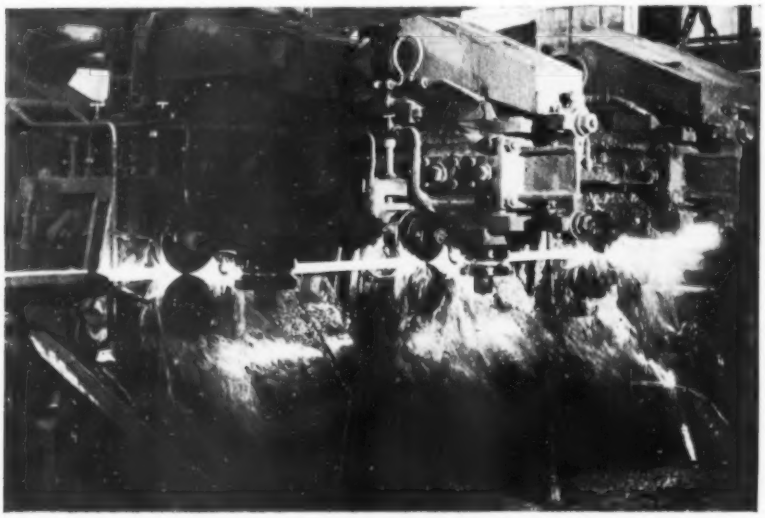
Administrative Building of the Deutsche Edelstahlwerke A.-G. in Krefeld.

wire : rolled, drawn ; tubes : hot-drawn, black, chill-cast ; press and forging steels ; cold rollers, drawing-dies ; parts for wire-drawing presses ; chilled metal Titanite ; prepared forging steel and turnings ; shear-blades ; and motor-car and aeroplane cylinders.

The Remscheid Works concentrate on the production of forged parts for motors and aeroplanes ; other types of vehicles and machine construction, especially crankshafts ; rough-forged or forge-pressings, rough-turned, machined, and polished ready for constructional purposes ; double-Duro tempered forged gearwheel parts, shaftings, clutch parts ; dredger bolts and bushes ; and Goliath forged blocks. While at the Verdohl forge bar steel is prepared in all kinds of sections, other specialities being discs, rings, small ingots, and small bars, alloy steel castings are made at the Bochum Works, especially heat-resisting Thermax parts used in furnace construction ; for glass and porcelain works ; rust and acid-resisting Remanite apparatus ; cast magnets ; Akrite and steel castings. Special chromium-tungsten-cobalt steel magnets for all purposes are made at the Dortmund Works, as also are Oerstit magnets for power loud speakers, with high accoustic properties. At the Hannover Works the specialities include crankshafts, and sheet metal in various states of finish.

The works are admirably equipped and organised for the manufacture of high-grade steel products, and the company occupies a leading position in alloy steel manufacture. Its sales side is well organised, not only in Germany, but throughout most important industrial centres abroad.

A Frecz-Moon mill in operation at Thyssen-Mülheim der Deutsche Rohrenwerke A.-G.



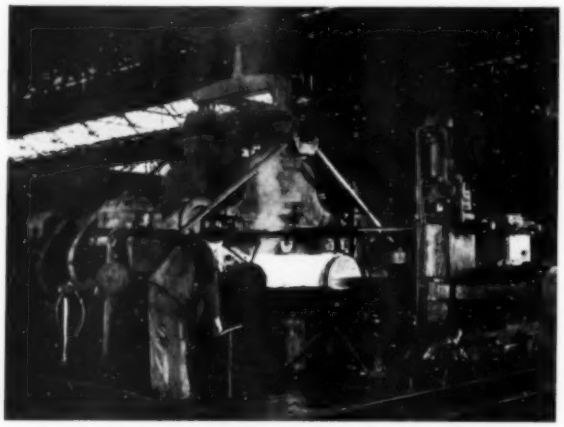
DEUTSCHE EISENWERKE A.-G., SCHALKER VEREIN, GELSENKIRCHEN.

FOUNDED in the year 1872, under the name of Schalker Gruben-und Hüttenverein, these works have grown to become one of the largest and most progressive in their fields. Originally consisting of a blast-furnace and owning its own coal and ore mines, large foundries have been added. The manufactures comprise blast-furnace and auxiliary products, and foundry products. The former include pig iron, Portland and blast-furnace cement, slag wool, and slag concrete blocks ; in the foundry the specialities are cast-iron pipes, machine castings, shaft rings, tubbings and tunnel rings, channel castings and castings for central heating. Machine shops are equipped for machining castings up to the largest size for the various engineering industries. The centrifugal casting plant is worthy of special notice, as during recent years the production of cast-iron pipes has been substantially accelerated, with improvement in both output and quality.

These works are now amalgamated in the Vereinigte Stahlwerke A.-G.

DEUTSCHE ROHRENWERKE A.G. (GERMAN TUBE MILLS.)

THE German Tube Mills Company (Deutsche Rohrenwerke A.G.) form a part of the gigantic fusion of interests organised



Roll-piercing process at the Phoenix works of the Deutsche Röhrenwerke A.-G

under the Vereinigte Stahlwerke, which controls groups which have an annual productive capacity of more than 10 million tons of pig iron and nearly a similar amount of crude steel, together with collieries with an annual output of about 40 million tons. This company was formed in 1933 as an independent working unit of the Vereinigte Stahlwerke (United Steel Works), with registered offices at Düsseldorf, with the object of uniting the steel-producing works of the main organisation.

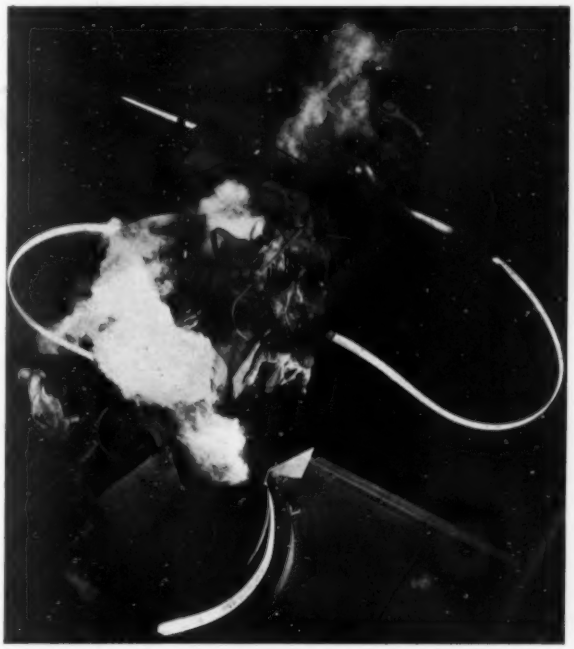
These tube works have an experience which extends over nearly 90 years, and some idea of their size may be gathered from the extensive plant, which includes 27 rolling mlls for seamless and welded tubes ; 11 rolling mills for producing the more general merchant forms of iron and steel, such as hoops, tube strip, and sheet. In addition to the mills, the works embrace tube-working and fitting shops, a

tube-welding shop, steel standard and steel cylinder works, a press shop, a galvanising shop, etc.

The programme of production, which has been developed over many years, comprises seamless and welded steel tubes, and steel tube products in all sizes and shapes. Some idea of the specialities of this company will be obtained when it is stated that seamless tubes up to 1,700 mm. diameter are made, and welded steel tubes up to the largest diameter practicable for shipping purposes. In addition to the ordinary commercial products and qualities, a great number of special products are manufactured at the two main works—viz., the Phœnix Works in Düsseldorf and the Thyssen Works in Mülheim.

The Phœnix Works enjoy a special reputation for seamless tubes, which are produced according to a special expanding process, and can be supplied in particularly thin thicknesses up to as much as 1,500 mm. diameter. For steam boiler construction, and also for the chemical industry, high-quality seamless tubes are produced for the highest pressures and temperatures, made of special heat- and scale-resisting steels. Similarly, the products made of " Sicromal " and " Deutro " steel by the Phœnix works, which is resistant to acid and compressed hydrogen, have been successful in finding a wide outlet.

Special products meriting mention of the Thyssen works in Mülheim (Ruhr), an enterprise which has developed out of the firm Thyssen and Co., founded in the year 1871 by Aurust Thyssen, are the Thyssen high-safety drum, of which as many as 12,000 units have already been supplied, as also the seamless steel elements (up to 1,200 mm. diameter and 8.3000 length) produced by the Rex Roeckner method in the radial rolling mills, and the continuous production of butt-welded tubes from iron-strip by the Fretz-Moon method. In addition, the Thyssen Works take a leading place in the production of strip, semi-finished steel in various forms, especially heavy and medium thick sheets, part of which are further elaborated at the Thyssen Works.



Strip rolling mill in operation at Thyssen Mülheim der Deutsche Röhrenwerke A.-G.

DORTMUND-HOERDER HÜTTENVEREIN A.-G.

THIS company comprises the plants of the former Dortmund Union and of the former Hoerder-Verein. The Hoerder-Verein originated in the Hermannshütte, which was established as a puddling and rolling plant in 1839-41. Later, in 1852, the Hoerder Bergwerks-und Hüttenverein was developed, which at that time was one of the first of the large steel-producing companies of Western Germany, and at the Paris World Exhibition, 1855, the quality of the products of the Hoerder-Verein was such that the works gained the gold medal for wheel sets, wheels, tyres, axles, rails, fish-plates, sleepers, and foundation plates. In 1879 the Hoerder-Verein introduced the basic Bessemer process, and was able to work the phosphoric ores of the district. In 1906 the Hoerder Bergwerks-und Hüttenverein amalgamated with the Phœnix A.-G. für Bergbau-und Hüttenbetrieb, and the fusion proved advantageous, as the products of the companies supplemented each other.

The origin of the Dortmund Union dates back to 1855. The works comprised puddling furnaces and a rolling mill, together with an iron foundry, repair shops, a forge, and a small gas works. In the same year the Dortmunder Hütte, as the firm was called, was absorbed by the Gustav Arndt Company. It was not until after 1869, when Dr. Strousberg acquired all the interests of the company, that development became possible. Strousberg spent large sums in extensions, and erected a bridge-building plant, blast-furnaces, coke-ovens, a wheel factory, and a Bessemer plant. Coal and ore mines were also acquired to make the company independent in regard to raw materials, the primary object being to manufacture railway stock and permanent way material. Later, in 1872, these works were amalgamated with the Union A.-G. für Bergbau, Eisen and Stahlindustrie, which had been formed by Friedrich Grillo. To this company were joined the Henrichshütte in Hattingen and the Werk Horst near Steele.

A decisive change in the history of the Union came in 1910, when it was amalgamated with the Deutsch-Luxemburgischer Bergwerks-und Hütten A.-G., directed by Hugo Stinnes. The transformation of the works was carried out on a large scale by the initiative of Dr. Albert Völger, and was practically completed by the end of 1913. With the establishment of the Vereinigte Stahlwerke A.-G., the Dortmunder Union and the Hoerder-Verein were united under one management, and as a result of the later re-

The blast-furnace plant at the Oberhausen works of Gutehoffnungshütte E.O.1.

The blast-furnace plant at Gutehoffnungshütte E.O.1.

organisation of the Vereinigte Stahlwerke A.-G., both firms were joined in the Dortmund-Hoerder Hüttenverein A.-G.

The products of this company include semi-finished material, rails and sleepers, steel sections, " Larssen " interlocking piling, steel rods, heavy and light plates and sheets, Universal mill products in the usual commercial and well-known Union qualities. Forgings, from the small round rod of normal quality to the largest hollow forgings of high-grade alloy steel. Steel castings up to the largest dimensions and in high-grade alloys. Points and crossings of all types for narrow gauge, normal gauge, and double track. Small steel sections for permanent way material and rolling stock parts.

GUTEHOFFNUNGSHUTTE, OBERHAUSEN, RHINELAND.

ESTABLISHED in 1750 were three foundries which obtained raw materials, in the form of charcoal and bog iron ore, in the vicinity of the present town of Oberhausen. In 1808 these were united in a single company, who manufactured under the name of Jacobi, Haniel and Huyssen, Mining Guild and Merchants, and which was converted in 1872 in the Gutehoffnungshütte A.-G., a joint stock company for mining and smelting.

The scope of these works is very comprehensive, and embraces coal-mining, smelting, steel manufacture, and the production of various forms of finished and semi-finished steel products. Coal-mining is carried on at seven pits, and coke-ovens and an extensive plant for the further development of the coal are adjoining. In addition, the company possesses iron-ore mines, limestone and dolomite quarries.

The smelting works and rolling mills comprise blast-furnaces, Thomas and Martin steel works and corresponding mills for producing railway superstructures, sections, sheet, bar and other products of the rolling mill. Adjoining are departments for producing paires wheels, a stamping shop, a Thomas slag mill, cement works, and a plant for producing refractory bricks.

The works at Sterkrade originated at the time of the inception of the smelting works, and form one of the oldest enterprises of the kind in Germany. A wide range of products are made at these works, and special mention may be made of steel bridges ; structural and hydraulic engineering ; blast-furnace, steel, and metal works buildings ; general industrial engineering ; mining engineering ; boiler, tank and equipment construction ; shipbuilding ; turbo and general mechanical engineering ; and switch-making.

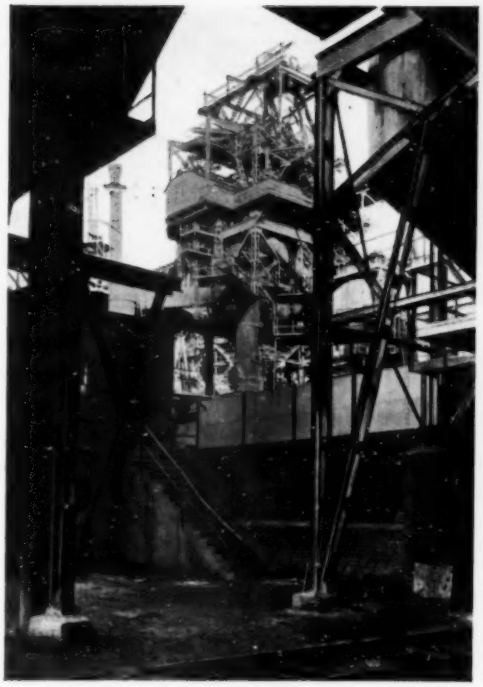
The drawing and engineering offices are very elaborate, particularly that part in which the construction of complete blast-furnace plants are planned, designed, and supervised. Here, not only is all the preliminary work prepared for blast-furnaces, but also for acid and basic Bessemer steel-works, acid and basic open-hearth steel furnace plant, and rolling mill plant.

It is only possible to give a brief summary of the ramifications of this company. Thus, the works at Dusseldorf carry on the tradition of the old-established firm of Haniel and Lueg ; this latter concern, in addition to castings and forged parts, manufactures piston pumps for larger capacities, hard stone crushing, dressing and sintering plant. Also in Dusseldorf is the well-known firm of Schloemann A.G., whose rolling mill and hydraulic press plants are constructed by the works attached to the concern, and more especially by the Dusseldorf section of the Gutehoffnungshütte.

Krupp's Works Port and blast-furnace plant.

The shipbuilding yard of the company at Walsum (lower Rhine) is one of the most modern and efficient yards for producing river, canal, harbour, and coast vessels. The Gelsenkirchen works include a wire-rope and chain factory, while at Schwerte is an affiliated bolt and cold rivet producing factory.

The Gutehoffnungshütte concern comprises in addition quite a number of well-known works, such as the Augsburg-Nuremberg Company ; Nuremberg, Augsburg and Gustavsburg ; the Esslingen Engineering Company, Esslingen ; the German Shipbuilding Company, Hamburg ; the Osnabruck Copper and Wire Mills, Osnabruck ; the Nuremberg Iron Works, formerly J. Tafel and Co., Nuremberg ; the Augsburg Gear Works, formerly Joh. Renk, Augsburg ; the Swabian Smelting Works, Wasseralfingen ; the Deggendorfer Shipbuilding and



A blast furnace at Krupp's

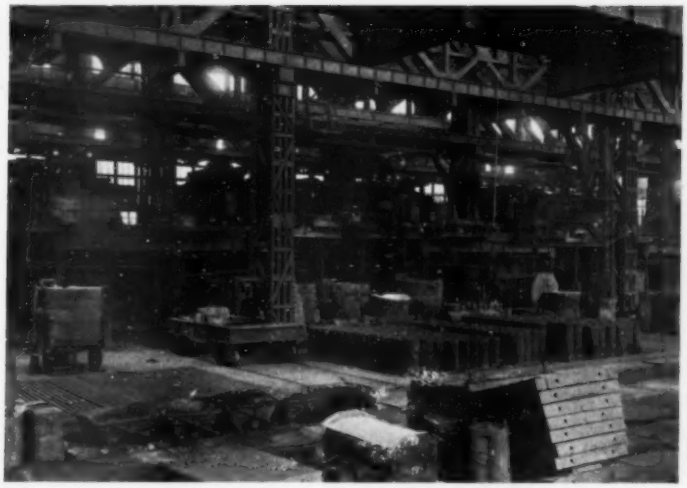
Engineering Company, Deggendorf; the Hackethal Wire and Cable Works, Hanover; and has also several merchant and shipping companies.

Visitors inspecting the working plant of the Gutehoffnungshütte in Oberhausen and in Düsseldorf will find much of interest. In addition to the smelting plant, the fine gauge sheet and medium sheet mills are of special interest; they are considered to be the best mills Schloemann's have produced. A works' exhibition, organised in Oberhausen, provides a comprehensive survey, by means of working models and equipment, of the activities of the concern, while an underground visit gives a comprehensive impression of its mining activities.

HOESCH-KÖLN NEUASSEN AKTIENGASELLSCHAFT FÜR BERGBAU HUTTENBETRIEB.

THE Hoesch iron and steel works began in the first decade of the nineteenth century when Eduard Hoesch started a small plant with one blast-furnace and a hammer in the Eifel district. In 1871, Leopold Hoesch, his sons, and the sons of his deceased uncle Eberhard, concluded an agreement to found iron and steel works at Dortmund. About three years later the plant was put into operation, and it has developed from that time. A basic Bessemer plant was installed in 1884.

Following 1891, when the steel output of the Hoesch works amounted to about 5% of the total production of steel in Germany, the active work of Friedrich Springorum completed its transition into a vertical combine concern by the erection of its own blast-furnaces, as well as by the acquisition of its own coal and ore mines in the Siegerland and in Sweden. Extension on the finishing side by the installation of new plants and by amalgamation with finishing works, completed this evolution. The company's growth reached another stage in in development in 1930 by the fusion with the Köln-Neuessener Bergwerksverein, one of the largest coal companies. The products of the company and its subsidiaries include the products of the steelworks, rolling mills, special rolling mills, wire mills, forges, refractory brickworks basic Bessemer slag mills and grease works and also the finished iron and steel products of its subsidiaries.



An inside view of the open-hearth plant at Krupp's.

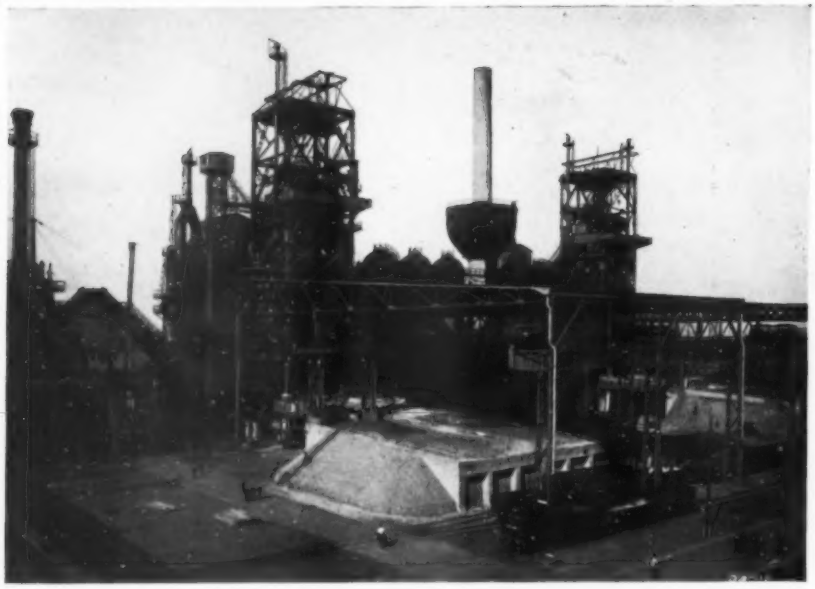
FRIED. KRUPP A.G.

FOUNDED nearly 125 years ago as the Essen Cast Steel Works, the Krupp Works have grown into one of the most prominent industrial concerns in Germany, and to-day the firm of Fried. Krupp A.G. is one of the best-known iron and steel-making concerns in Europe. The company own coals and iron-ore mines, blast-furnace plants, and steelworks, foundries, forges, and rolling mills, engineering works, and a shipyard. Ores from overseas are transported by the company's own steamers. The company has acquired a controlling interest in a number of other manufacturing firms and trading companies, and its field of activity is remarkably wide. At the present time it gives employment to over 80,000 men, including the staff.

The visits embrace the Essen Works and the Friedrich-Alfred-Hütte Works at Rheinhausen. The former works, situated in the very centre of the Rhenish-Westphalian industrial district, is the original undertaking and parent establishment of the Krupp organisation. These works comprise two main groups: a steel section and a mechanical engineering section, which occupy an area of 2,150 acres. The site is bounded on the north by the Rhine-Herne Canal, and a private harbour branching off the latter, 765 yds. long and 65 yds. broad, affords excellent facilities for receiving and despatching goods by water.

The "Steel Section" of the Essen Works comprises two blast-furnaces, each capable of producing 500 tons of pig iron per day; four separate open-hearth steel plants, with a total of 20 furnaces; an electric steel plant of nine furnaces; a forging department for smith and die forgings, in which are installed 77 steam hammers and 15 forging

The converter platform of Krupp's Thomas steel work.



Blast-furnace plant at Essen-Borbeck, Krupp's.

presses ; two large forging-press shops installed with forging presses of 15,000, 5,000, 4,000, and 2,500 tons capacity ; seven rolling mills for semi-finished material, medium and small structural sections, strip and wire rods ; three plate and sheet mills ; a tyre rolling mill and a wheel rolling mill ; three shops for the construction of railway wheel sets ; a plate-pressing department equipped with 16 flanging and drawing presses, having a total capacity of about 10,000 tons per annum ; a spring department ; two large steel foundries producing casting up to 160 tons ; two grey iron foundries ; two foundries for special castings ; one non-ferrous foundry ; five extensive machine shops for finishing forgings and castings up to the largest dimensions ; and a department for the manufacture of chemical apparatus, storage tanks, and similar articles manufactured in corrosion and acid-resisting steels.

Consistent high quality in production is ensured by the minute supervision exercised by the central Research Laboratory, which is equipped with the most modern chemical, physical, micrographic and electrical apparatus. This central Laboratory controls a considerable number of individual testing and experiment stations spread over the entire works. The Research Laboratory is also continuously carrying out scientific investigations, which in the past have led to developments of outstanding importance in the metallurgical field.

The principal products of the " Steel Section " are : High-grade special steels of every description, such as high-speed and carbon tool steels, " Widi " cutting metal for tipping tools, special constructional steels suitable for treatment by oil quenching, case-hardening, and nitrogen-hardening, hard-wearing high-manganese steel, die steels, rifle barrel steels, steels possessing specific electric, magnetic, or thermal properties, non-rusting, acid-proof, and heat-resisting steels ; semi-manufactures, bars, strip, and wire rods of special analysis steel ; forgings of any size and description, steel and iron castings up to the largest sizes and of the most intricate shapes, malleable castings, non-ferrous castings, rolls for cold-rolling mills, weldless pressure vessels, parts for automobile, aircraft and engine construction, railway wheel sets and parts for same, springs, plates, sheets, and pressed platework.

The " Mechanical Engineering Section " comprises complete locomotive shops with a total capacity of 400 heavy locomotives per annum ; a department for the manufacture of various types of petrol and Diesel-engined motor lorries, an agricultural machinery department, and complete plants for the manufacture of light railway material, railway and tramway points and crossings, excavating machinery, soil transporters, complete gear drives up to the largest dimensions toothed gearing of every description portable pneumatic and electric tools, and many other kinds of machinery and appliances.

FRIEDRICH-ALFRED-HÜTTE WORKS.

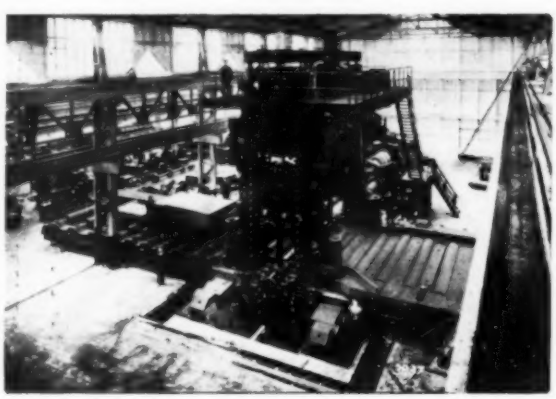
During the years 1896-1897 the Friedrich-Alfred Hütte was started with three blast-furnaces and the necessary auxiliary plant. From 1904 onwards, blast-furnaces, various steelworks and rolling mills, have been added, with the result that the works now rank equal to any in Europe. The large capacity of these iron and steel works, which occupy a total area of 1,621 acres, is mainly attributed to its favourable position on the banks of the Rhine. For discharging the incoming cargo boats there is a harbour available of approximately 20 acres useful water surface.

The blast-furnace plant produces all kinds of pig iron. Most of the pig iron is utilised in the steelworks—*i.e.*, in the Thomas work with six basic converters, and in the open-hearth works. The rolled products are : Blooms, slabs, sheet, bars, permanent-way material, such as rails, sleepers, fish-plates, sole-plates, bolts and nuts, etc., for broad and narrow gauge, for mining and field tracks, crane rails, rolled shapes, and steel bars, wire rods, etc.

An important part of the Friedrich-Alfred Hütte is the steel structure and bridge-building department, equipped with the most modern plant and machines. Important constructional contracts, as bridges, shipyards, factories, lattice poles, river-spanning towers for high-tension power, transmission lines, trolley-wire poles for electric railways, and tramlines have been carried out both in Germany and abroad.

The blast-furnace department at Rheinhausen comprises nine large blast-furnaces, and two smaller ones which are used for making high-grade ferro-alloys. The furnaces stand in a line 1,325 yds. long, facing the company's harbour, which opens on the River Rhine and is equipped with ample facilities for rapidly loading and unloading vessels berthing at the quay. The steel-making department, which receives most of its raw material in the form of hot metal, comprises six basic converters of 25 tons capacity each, and two open-hearth shops with eight furnaces in all ; four of the latter, each of 160 tons capacity, being of the tilting type. The rolling-mill department consists of 15 mills, viz., three heavy blooming trains, five roughing, three intermediate, and three finishing trains, and one wire rod mill of very high capacity.

Blooming mill erected in the works of Maschinenfabrik Sack A.-G., said to be the largest in Europe.

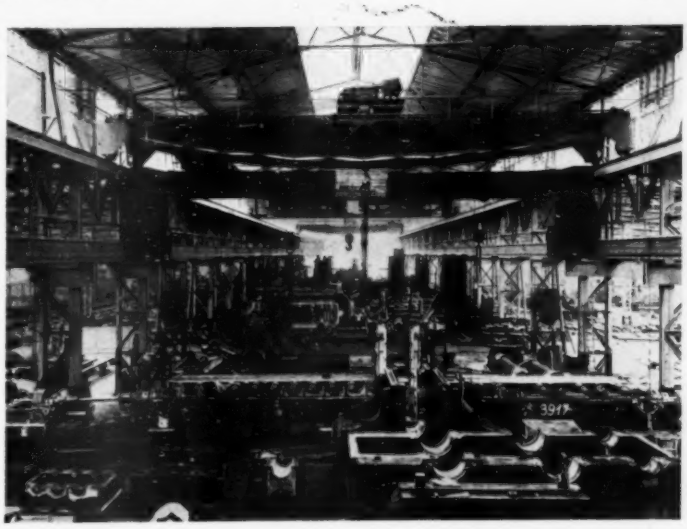


MANNESMANNRÖHREN-WERKE A.-G.

THIS company, which is among the most important mixed combines of the heavy industry, was established in 1890. The manufacture of seamless steel tubes, developed as a result of the process invented by the brothers Mannesmann, was the basis of the company's activities. Improvements in the process rapidly led to the domination of both home and foreign markets by the Mannesmann steel tube, and thus to the extension of the plants. During subsequent development, the Mannesmannröhrenwerke acquired their own sources of supplies of ore, steel, and coal. Even prior to 1914 the works included plate, medium, and thin sheet rolling mills, and later the range of products was extended by the installation of an efficient rod and sections mill.

The largest tube works of the combine are the "Division Rath" at Düsseldorf, which manufactures seamless steel tubes up to the largest known dimensions and in all thicknesses. These works also include large finishing plants and supplies, in addition to water, gas, and heating pipes, drilling and connection pipes, also coiled systems up to the largest dimensions, steel cylinders, masts, ship-building material, etc. A special division produces vats and containers of all descriptions from sheets produced in the company's own mills.

The largest steel works of the combine, the "Heinrich-Bierwes-Hütte" at Duisburg-Huckingen, has grown out of the plate mills "Schulz-Knaudt," acquired in 1914, and consists of blast-furnaces, basic Bessemer, open-hearth, and electric steel plants; plate and section mills; finishing plants for welded tubes, pressings, boiler drums, etc.; and numerous subsidiary plants are associated with the combine.



Large blooming mill in course of erection at Maschinenfabrik Sack A.-G.

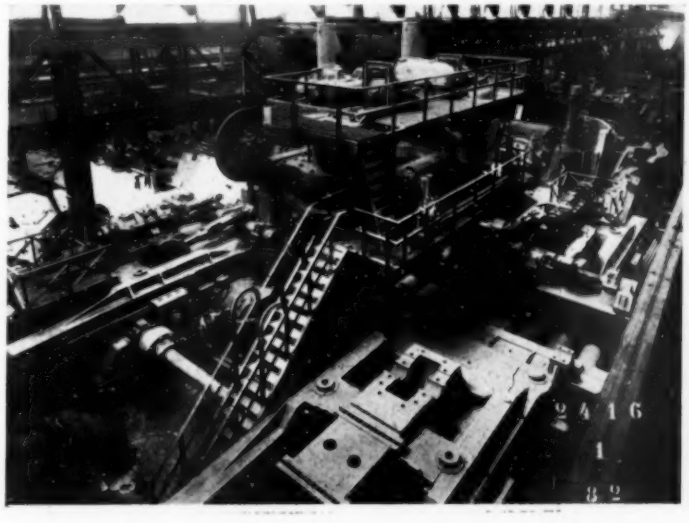
WORKS OF MASCHINENFABRIK SACK.

SINCE its inception 35 years ago, the company of Maschinenfabrik Sack G.m.b.H., of Düsseldorf-Rath, has grown in importance, and now occupies a prominent position as one of the leading designers and manufacturers of rolling mill and auxiliary machinery in Europe. Although the chief products of this company consist of rolling mills of every size and for every purpose, its greatest speciality is the design and construction of heavy mills for the production of blooms, slabs, billets, heavy plates, rails, joists, etc., and a very high degree of success has been achieved, but the efforts of this company have met with equal success in the design and construction of smaller mills for the production of sheet bars, merchant bars, wire rods, and all classes of small sections, both for ferrous and non-ferrous materials.

In addition to rolling mills, steelworks auxiliary machinery, such as electrical and hydraulic shears, rotary shears, cooling banks, roller tables, electric rollers, plate-bending and flattening machines, roller-straightening machines, ram-straightening and bending machines, and the like, are also a speciality. This company has also patented and designed a modern horizontal upsetting forging machine, one of which was recently put into operation in Great Britain for upsetting 7-in. diameter bars, amongst many others of smaller size down to 1-in. bars. Various special machines have also been designed and patented for the production of solid-drawn tubes. Particular mention may be made of a reducing machine of the multiple triple-roller type, and also tube-bending and tube-flanging machines.

The works cover a large area, the machine and erecting shops in particular being large and equipped with the most modern tools available. The erecting shop is capable of taking the largest rolling mill housings up to a height of 40 ft. or more from the ground level. Of particular interest in the machine shop is the complete equipment of gear-cutting machinery; this comprises machines of the latest European and American designs, the largest being capable of cutting double helical gears up to a diameter of 22 ft. by 8 ft. across the face. Every gear wheel used in the construction of this company's specialities is cut in this machine-shop and carefully tested before erection.

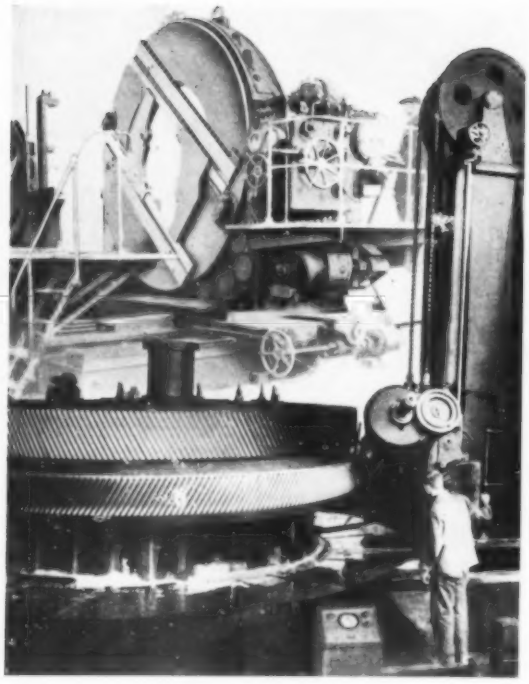
View in main shops of Maschinenfabrik Sack A.-G.



All small forgings necessary are produced in these works, and the forge has facilities for demonstrating the company's special upsetting and forging machines, but all castings and heavy forgings are supplied to requirements by outside firms.

The erecting shop is fully equipped with electrically driven high-speed travelling cranes, capable of dealing with loads up to 120 tons. An interesting feature in the machine-shop is the number of portable tools in operation. For machining heavy pieces, portable tools mounted on large central bedplates surround the heavy castings, which are completely machined with a minimum of setting-up reducing costs, and preserving the accuracy and precision of the finished work. The works are equipped with a modern ventilating and heating system, in order to maintain a suitable temperature for the workmen under all-weather conditions.

Some 50 to 80 draughtsmen are employed in commodious drawing offices, all of whom have been



Precision wheel milling machine for machining spur, helical, herringbone, and worm gears up to 5,000 mm. diameter and 2,200 mm. width, by Schiess Defries.
In background: Crank pin turning appliance for maching the pins and webs of heavy single and multiple cranked shafts, of 2,100 mm. clear diameter.

trained under the instructions of the directors, Dr. G. Asbeck, Herr Rusen, and the Chief Engineer, and the design and production of each special type of machine is in the hands of a trained specialist.

During the last two years this company has built what is claimed to be the largest armour-plate rolling mill in Europe, and is now designing a heavy plate mill, which, it is understood, will be the largest in the world. Mr. J. A. Smeeton, who represents this company in Great Britain, informs us that Maschinenfabrik Sack has designed, built, and installed a number of large blooming mills for British works during the last three years, some of which are now in course of erection.

SCHIESS-DEFRIES A.G.

THIS important machine-tool firm was founded in 1866 by Ernst Schiess, under whose capable management the enterprise made rapid progress. In 1906 it became known as the Ernst Schiess Machine Tool Works, which was changed to the Schiess Engineering Works in 1916. During the years 1923-4 a scheme of reconstruction was developed, and new buildings were erected and new machinery installed, and in 1925 an amalgamation took place with the Defries Company, resulting in the present Schiess-Defries Company.

The main field of activity of this company lies in the building of machine tools, especially large machine tools which require special manufacturing equipment. Such machines can only be designed and constructed successfully as a result of prolonged experience, and this company is in a favourable position to contribute materially towards improving quality and lowering costs in the steel industry, as well as in various types of heavy engineering.

These works are building some of the heaviest machining plant, up to maximum sizes which can be made having regard to transport facilities—*e.g.*, giant lathes with height of centre up to 3,000 cm., for turning turbine rotors, ships' shafts, and other heavy forgings; mighty planing machines up to 5,000 mm. in width and 30,000 mm. in length; vertical boring mills for turning diameters up to 22·5 m.; heaviest patterns of boring and milling machines, punches, shears, bending and straightening machines, and so forth, for smelting works and shipbuilding yards; special machines for producing "Tübbings," large gas engines, Diesel engines, steam turbines, etc.

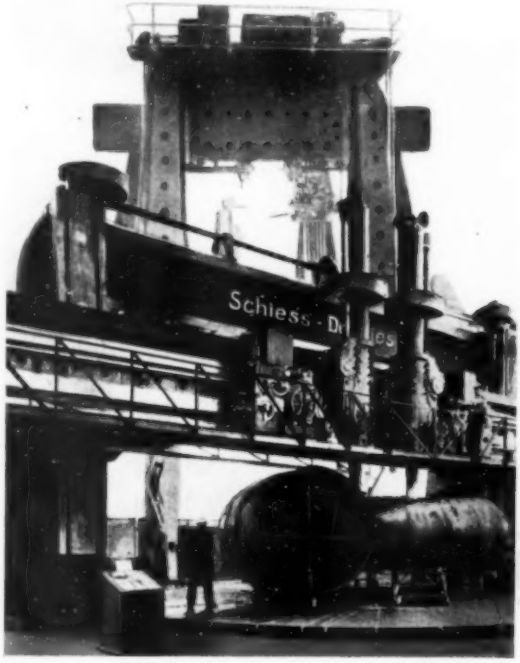
For railway purposes a large number of machines are constantly being produced on the basis of new viewpoints gathered from practical operation, for locomotive and carriage building, for the manufacture of axles and paired wheels, as also for machining rails, fish-plates, and switches, making a total of some 50 types of machines.

According to the principles of modern series production, furthermore, smaller and medium-sized machine tools of all kinds are produced—high-speed lathes, single- and double-standard vertical boring mills, horizontal boring and milling machines, steel grinding machines, cutter-head grinding machines, key-groove milling machines, etc., and, furthermore, the well-known horizontal forging machine.

High capacity is mainly a matter of equipping the works with the best and most modern mechanical plant. The mechanical shops are equipped with 600 machine tools, from the smallest to the largest sizes, and with electric cranes for all carrying capacities. The iron foundry is equipped for casting pieces up to a weight of 80 tons; it is provided with three cupola furnaces of a total melting capacity of 20–25 tons per hour; in addition, the works comprise a pattern shop, pattern and stock stores, as also a forge with pneumatic hammers and an iron sawing shop, together with hardening plant. The power equipment comprises more than 500 electric motors; also all other modern amenities, such as compressed air, handling, heating, lighting, and plant and sanitary installations, etc., are provided.

Attached to the Defries works is the works for lifting equipment, where the hand-hoisting appliances, "Stella," well-known at home and abroad, are built. These are produced in large series on modern machining plant, warranting the highest degree of accuracy. Both works cover an area of approximately 160,000 square metres, whereof approximately 75,000 metres are built over. In normal times 2,000 workmen and 300 employees are occupied.

Giant Vertical Boring Mill, 18 m. and 22·5 m. turning diameter, 5 m. maximum useful height, 700 tons weight.
In background: Large "portal" milling machine, 4·5 m. × 4·5 m. clearance, 28 m. bed length, 500 tons weight.



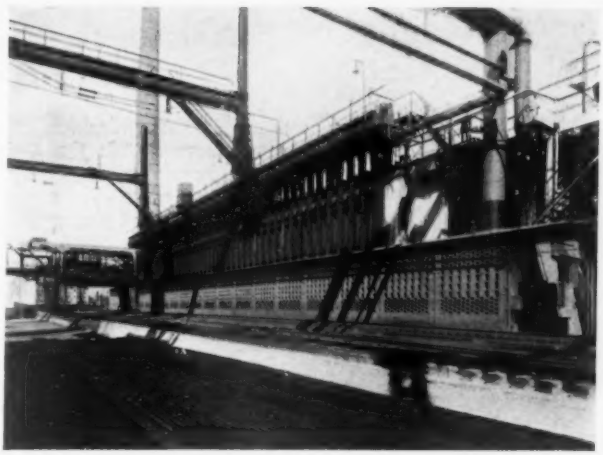
VEREINIGTE STAHLWERKE A.-G.

FOUNDED at the beginning of 1926 by a merger of a number of the oldest and most important companies engaged in the heavy industries of the Rhineland and Westphalia, the Vereinigte Stahlwerke A.-G., Düsseldorf, is the largest single combine of the basic industries in Europe. The wide financial basis, the capacity of the numerous constituent works, the great experience in the operation obtained by them through many decades, and the exceptionally wide range of products, were the foundations for the healthy and successful development of the new combine. With a view to securing continuous increase in the technical and economic productivity of the amalgamated works, a comprehensive rationalisation of the organisation of the combine was undertaken, and this was completed about three years ago. Production was systematically divided into the following main groups—coal mining ; raw materials ; iron and steel works, and finishing plants. Works were allotted to these main groups after consideration of specific and regional questions, the location of the plants, their layout, organisation, and past experience in production ; these groups, in the course of a further decentralisation of the administrative programme, were transformed in 1933 into legally independent subsidiary companies.

These operating subsidiary companies are : The Gelsenkirchener Bergwerks A.-G., which administers valuable coal and coke properties ; the August Thyssen-Hütte A.-G., with five large steelworks on the Rhine ; the Dortmund-Hoerder Hüttenverein A.-G., with iron and steelworks at Dortmund and Hoerde ; the Bochumer Verein A.-G. for steel castings, with numerous departments manufacturing special steels, as described elsewhere.

These three groups of steelworks form the foundation of the iron and steel production of the Vereinigte Stahlwerke. They are closely connected with the following operating companies—themselves organised by products—which are their important customers : The Deutsche Eisenwerke A.-G., with blast-furnaces and foundries ; the Deutsche Röhrenwerke A.-G., the largest European tube concern ; the Hüttenwerke Siegerland A.-G., with numerous sheet works ; the Wurag A.-G. ; the Westfälische Union für Brückenbau A.-G., wire products ; the Baudeisenwalzwerke A.-G., strip ; the Dortmunder Union Brückenbau A.-G., bridge and constructional engineering ; the Siegener Eisenbahnbedarf A.-G., railway material ; and several finishing works operating in the form of limited liability companies. In addition, the Vereinigte Stahlwerke are interested in a large number of other undertakings in the heavy industries.

The " Prosper " coke-oven plant of the Rheinische Stahlwerke A.-G



The " Mathias Stinnes " coke-oven plant of the Gewerkschaft Mathias Stinnes in Essen.

COKE-OVEN PLANTS.

ARRANGEMENTS have been made to visit the central coke-oven plant " Prosper " of the Rheinische Stahlwerke A.G., Abt. Arenberg, Essen, and the " Mathias Stinnes " plant of the Gewerkschaft Mathias Stinnes in Essen. The " Prosper " coke-oven plant, which is the largest in Germany, was built to centralise the carbonisation of coals which came from different collieries of the Rheinische Stahlwerke, some of them being located at considerable distances from one another. The first 180 ovens were erected by Dr. C. Otto and Co. G.m.b.H., Bochum, in 1928. These are arranged in four batteries, two being of the new Otto compound type, with twin flues, which can be heated either with producer gas or coke-oven gas. The other two batteries, being also of the hairpin type, are heated with coke-oven gas only.

The plant has recently been extended by the erection of one more battery, consisting of 45 Otto twin-type flue compound ovens. The chambers throughout the five batteries are 45 ft. in length, 13 ft. high, and the average width is 18 in. The plant is now capable of dealing with 4,800 tons of coal per day.

At the Mathias Stinnes Colliery the first Otto battery of ovens was started in 1927 ; they were dimensioned to suit the compound ovens already installed, having a length of 36 ft., height 12 ft., and an average width of 18 in. The guaranteed throughput of these 30 ovens was 400 tons of dry coal per day, at a gross coking time of 20 hours, in other words, 36 ovens should be pushed per day. However, in actual working, 45 ovens could be pushed per day, and a throughput of 540 tons of dry coal was obtained which would correspond to an increase of 50%.

As a result of these highly satisfactory results, another battery of 50 ovens was installed of similar dimensions to the existing ovens. For this last battery a guaranteed throughput of 750 tons of coal was given, corresponding to a gross coking time of 18 hours. It is noteworthy, in connection with this battery, that during tests carried out by the Coal Syndicate in 1931, over a period of two months, this performance was by far exceeded, and a gross coking time of $11\frac{3}{4}$ hours and a throughput of 1,120 tons of coal was obtained.

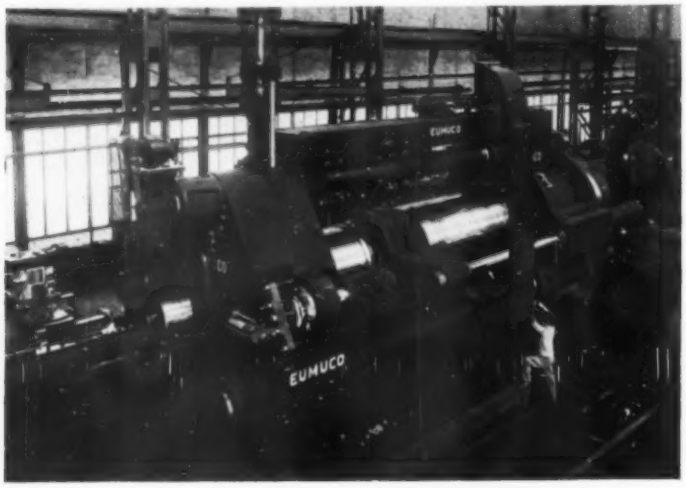
It seems only a few years ago that coke-ovens of an average width of 18 in. required a coking time of 24 hours, but lengthy studies and intensive research work during recent years have raised the efficiency of coking plants to a remarkable degree, and these visits should prove both interesting and informative. Messrs. Simon-Curves, Ltd., Cheadle Heath, Stockport, are associated with Dr. C. Otto and Co., the builders of these plants.

Modern Extrusion for Tube Manufacture

By GILBERT EVANS

The adaption of hydraulics to the piercing and extrusion of non-ferrous metals for finishing into tubes is discussed. Vertical and horizontal types of presses are compared, and a description given of a modern horizontal press which is the outcome of prolonged research and experiment.

EVEN as recent as 1926 much scepticism was expressed with regard to the adaption of hydraulics to the piercing and extrusion of non-ferrous metals for the purpose of finishing into tubes by the cold-drawing process. The fears were well founded, and it has taken years of research and practical experiment to assure the confidence which at present exists in the possibilities of the process as a commercial success. The biggest bane of tube manufacturers has always been eccentricity of wall thickness, a fatal defect, when considered in connection with the close limits allowed in this respect and also to limits in diameters, and to cope with such close demands the finishing of tubes may be classed as precision work.



3,500-ton Hydraulic Extrusion Press for non-ferrous metal sections and tubes.

These remarks applied until the last two years, particularly to the horizontal press, in the operation of which several factors had to be taken into consideration—viz., the liability of the solid billet to loss of diameter by overheating and wasting, due to having delay in the case of a hitch in the working routine; also, there was the natural law of gravity or the proneness of the heated billet to lie on the bottom of the receiving chamber, resulting in any disparity in the diameter of the billet, and the bore of the containers throwing all the difference to the top side, and so upsetting the actual dead working centre of the machine.

The introduction of the vertical type of press remedied to a large extent such weaknesses, and this type was also a great economiser of space, being mounted on a platform about 14 ft. above floor level, or, with the excavation of a suitable chamber below the mill ground line, on the floor level. The writer, having experienced practice over a number of years, unhesitatingly recommends the adoption of the raised platform.

From the foregoing remarks, it would seem that the defects of the horizontal type of press would be a serious handicap in considering the installation of such a plant, but recent progress in design and construction has raised this class of press to a degree of excellence which few familiar with earlier practice dared hope. Considerable research and experiment has resulted in the design and construction of the Eumuco horizontal press, to which this reference especially applies, a description of which will appeal to those interested in the tube industry.

In coming to a definite decision as to the ultimate design, the engineering staff had to obtain the best available data on three most important points :—

(*a*) Possibilities of improvements of design for the hydraulic operation.

(*b*) Adaption of the tools to the conditions regulated by the material to be extruded.

(*c*) Improvements in design which aim at greater manufacturing accuracy, and consistent dimensions in extensive production.

One instance will serve to illustrate the difficult factors with which, in general, the designers of presses of this type are faced—viz., the relation between the material, the temperature of the material, the deformation degree,* and the specific pressure to be applied. The research alone in these specified aspects extended over a very long period before any attempt was made to formulate the data, which in its completeness was finally put to a severe and searching test in practice. Reverting to the points made under the three sections mentioned above, it will be of interest to discuss these in detail, in view of the success which has been attained.

Developments under (*a*) included: Increase in mechanical efficiency due to more scientific design; the reduction of friction; improvements to the control gear by using stainless steel for the seats and the cones of the valves; revised methods devised to ensure quick and easy control; regular and efficient water supply, resulting from the modern high-pressure air hydraulic accumulator, with its numerous advantages; and the adaption of approved designs of other hydraulic machines to the extrusion press.

Developments under (*b*) are characterised by alterations in design, whereby the more difficult metals can now be extruded satisfactorily and on a profitable basis, coupled with the ability to maintain a high production.

Developments under (*c*) have resulted in increasing the accuracy to a very high degree, the modern press giving a uniform section to a guaranteed basis and concentricity when producing tubes— $\pm$ 5% limits of accuracy is the usual commercial accuracy maintained.

Increased production coupled with the improved quality of the work at a reduced cost is the final result of these developments.

The investigations carried out under the headings (*b*) and (*c*) are of a specialised nature, and involved the design and metallurgical specification of the steel tools which would stand up to the high pressures and temperatures encountered, under high-friction conditions.

Having determined the nature and design of the best tools for the purpose, the next step was to ascertain the conditions governing the question of accuracy, apart from the tools themselves, and it may be mentioned that while it was possible to obtain accuracy with solid sections, such

* The author defines "deformation degree," as applied to the production of rods, the ratio of the cross section of the receiver to the cross section of the rod, and in case of the extrusion of tubes, the ratio of the cross section of the punched billet to the cross section of the corresponding hollow section.

was much more difficult where hollow sections were concerned.

Success has been attained recently in designing presses in such a manner that the difficulties arising from unequal expansion due to heat are completely eliminated. This success was obtained by coupling the ram head and receiver head rigidly together as a complete press, and then arranging the press itself so that the ram head virtually rests on a pivotal bearing, and the receiver head rests on a roller bearing at the other end of the same base plate or casting. It is thus possible for the centre line of the press to oscillate about the bearing under the ram head and for elongation to take place without this centre line being thrown out of truth.

The homogeneous nature of the metal billet is a technical matter for the foundry, and the question of unequal heating is a matter of furnace equipment and control. In order to make it possible for all billets to have the same temperature and to obtain equal heat throughout each billet, it is essential to have close control of the furnace temperature. The closest control is probably obtained with the electrically heated furnace, but some modern designs of furnaces heated by oil or gas, also give satisfaction. Given good heating conditions, it is necessary to transport the billets at equal intervals and with the minimum possible loss of heat to the charging tray of the press. If high production is desired, mechanical means must be adopted for the transport of the press plates. With the whole of the billet equally heated, and its transport to the receiver at a sufficient temperature facilitated, there are essential conditions to be met with in the design of the press in order to produce accurate results. The receiver must be heated in a suitable manner, otherwise the billet will not be heated regularly throughout its dimensions, and irregular walls in the subsequent extruded section will be formed. In modern designs this has been provided for by electrical and gas-heating systems, which have proved satisfactory in service.

Of greater importance, however, was the unequal expansion of the cross head of the receiver and the subsequent offsetting of the axis of the receiver from the main axis of the press. If the cross head has a firm support below, it cannot move in that direction, and the unavoidable expansion will take place in a vertical direction, so that the axis of the receiver is offset vertically. An oscillating movement was arranged for the press axis to allow for this expansion of the receiver in a vertical direction, by resting the ram head end of the press on a pivotal bearing, the press itself consisting of receiver head and ram head very rigidly connected by powerful longitudinal tie-bars.

The bearing for the receiver head is of a type which, while giving full support, permits movement of the head and so provides for any lateral expansion due to the heat. The axis of the press, which in effect includes the axis of the receiver and similarly that of the pressure punch or punching mandrel, is therefore kept true under all conditions.

Owing to the expansion of the receiver head, the slide for the guide of the main ram is made integral with the ram-head casting, and so has no direct connection with the receiver head or the longitudinal tie-bars, and is therefore not influenced by the heat expansion. This is very important, as the fine adjustment provided on the guide makes it possible to set the centre lines of the pressure punch, and with it the piercing mandrel, in correct alignment with the centre line of the receiver. This fine adjustment, once made, will remain constant independently of the temperature of the receiver of the billets altering, or if between two pressings there are differences of temperature.

As will be seen from illustration this guide for the moving cross-head is made very long, so that the transverse stresses can be absorbed safely and without the possibility of offsetting the centre line of the cross-head and thus of the pressure punch and of the punching mandrel. Similarly, the slides on the arm are equally long.

2,000-ton Hydraulic Extrusion Press for sections and tubes in various metals and alloys.

In order to complete the design, the press plunger is not connected rigidly to the moving cross-head, but by a self-aligning joint, so that any misalignment of the plunger does not affect the cross-head slides. This also prevents undue wear taking place on the plunger packing boxes.

The plunger is supported at the front and rear ends by the cylinder packing boxes, the cylinder itself being fastened to the main ram head, and therefore the cross-head slide. The punching rod and also the punching mandrel, when in use, are similarly provided with a self-centring type of joint at their bases, in order to ensure independent alignment.

It therefore follows that the moving cross-head, the pressure punch, and the punching mandrel form a self-contained unit, the directional accuracy of which is controlled by the moving cross-head slides, and, in this manner, true concentricity is obtained between the pressure punch and the punching mandrel, and similarly between the pressure punch and the bore of the receiver, so that uniform thickness of the walls of hollow sections is assured. It will be appreciated that this design also ensures that the outer skin of the billet is not forced into the extruded product owing to the pressure rod remaining central during the extrusion process.

With regard to the design of the tools, several points are of special interest. In this special design of receiver provision is made for quick removal of the top half of the casing, permitting a smart exchange of receiver holder and box, so that preliminary heating of one set can be made while another set is operating. This operation can be carried out within 20 to 45 minutes, according to the size of the press, representing a considerable saving in time and increased production. Owing to the special design, the receiver is automatically self-centring, following such exchanges.

Separate hydraulic operation provided for the punching rod and mandrel ensures quick withdrawal for cooling and clearing purposes, and special provision is also made for easy detachment of punching rod and mandrel. There are several alternatives arranged for severing the extruded product from the billet remainder, either hydraulic shears, a pendulum saw, or the die punching-off method. The die is displaced by an additional movement of the punching rod and locked in position by hydraulic closing wedge.

It sometimes happens that the tube or the rod does not sever from the die. In this instance an ejecting collar is provided, actuated by the punching mandrel, and clears

the die by an additional movement of the punching rod. Care has been exercised in the design to make all packings easily accessible, so that interruption of work for a new packing need not occasion any appreciable loss of production time.

Materials and workmanship are a very high standard, and all parts requiring close limits, such as the hydraulic plungers, are ground in order to reduce subsequent wear to a minimum. Valve bodies, etc., are machined from the solid forging, and the valves and seats are manufactured in hard bronze or stainless steel. Control gears have been designed to facilitate ease and speed of operation.

The writer acknowledges the courtesy of the makers of the Eumuco horizontal press in granting permission to present an analysis of the principa; features of this press.

Forging Chromium Steel Valves

By A. G. AREND

Forging work generally has been enhanced by the development of chromium steels, which lend themselves to comparatively simple pressing operations, but care must be exercised in the heating and cooling operations.

THE successful forging of valves in chromium steel very largely depends upon the softening of the metal when heated to a bright orange temperature. After chilling either in air, water, or preferably in oil, the natural hardness and rigidity is obtained which makes the product suitable for all classes of valves.

At the present time, probably the vast majority of forged valves are used for automobile purposes, but this might be regarded as a preliminary opening for a much wider future development. Engine valves are forged, more or less by the same process, whilst a distinct advance has been made by the forging of valves used for different distillation and other similar chemical plants. The resistance to tarnishing is not of so much importance for ordinary automobile purposes, but is imperative in the case of chemical plant valves. It is not likely that any heat-treatment accorded to the finished forged section will unduly affect the corrosion-resisting properties of the metal, but this point must be closely scrutinised.

In the case of valves for automobiles, or engines, any slight increase of the corrosion is not of so much account, since petrol or steam alone have to be contended with. Steels rich in chromium resist the formation of scale during forging to a considerable extent. They are thus adapted to high-temperature uses, such as engine-valves, apparatus for distillation, etc.; they may also be regarded as most suitable for automobile valves because of the ease with which the forging may be completed, and the hardness obtained from the finished part.

The process of forging is more or less the same when producing valves for petrol motor, steam engine, or chemical plant, although the constructional designs of each vary widely. The forging does not, of course, complete the valve, but obviates the tedious foundry system of casting, dressing, etc.

The steels used include those containing upwards of from 12 to 14% of chromium, and a widely varying carbon content. But to this must be added the richer chromium steels, and also those containing a small proportion of cobalt. Most of the forged sections of the latter metal at the present time consist of small parts, such as blades of knives, dental instruments, etc., etc. The high cost of the cobalt addition has done much to prevent the wider adoption of these steels for valve purposes. When cobalt is included, the metal retains its hardness almost unchanged, up to the point of redness.

It will thus be understood that valves used on distillation apparatus are eminently suited when made of rich chrome-steels containing a small percentage of cobalt.

The Forging System

One of the outstanding advantages of forging these valves is that the usual wastage from flash and from turning before grinding is almost unknown. The valves are forged by the extrusion method, and are directly finished by grinding without previous machining. When initially prepared, the metal is cast into ingot moulds, which are first forged or rolled into bars. Blanks are first cut from these bars, and the valve extruded in two operations.

When the rectangular hole is required, it is punched in the end of the stem, after which the stem is trimmed to length in a second press. This is followed by straightening, after which the valves leave the forge for the final grinding operation.

With one of the up-to-date plants, four bars of the steel go through the cutting shears at once, and four blanks are cut at each stroke of the shear. The blanks are then transferred to a furnace and heated for a few minutes at a temperature of approximately 1,200° C. The hot metal is directly placed in the first die, and the stem extruded by the punch. The second punch makes the desired slots. A smooth stem is thus obtained, which is very close to the desired size, whilst the slight amount of surplus metal goes into the stem, and is trimmed off the end at the same time. The outer die ring, and the die insert and punch, are made of high-speed steel, and the dies and punches are well lubricated, but without the need for any cooling. The success of the process is indicated by the speed obtained and the practical elimination of wastage.

Dies and Punches

The dies and punches are so constructed that those parts which are subjected to the greatest wear can be readily replaced or renewed. The valve, whilst still hot from the extrusion process, goes to the punching and trimming dies. The valve head is held against a stop by a stiff spring, whilst the end of the stem is supported in a close-fitting bushing, which acts as a die when the rectangular hole is being punched. Gauges are used throughout to ensure that all parts of the punches and dies are made to correct contours and sizes. This is done with a view to economising time and in providing an adequate supply of interchangeable replacement parts.

As regards the structure of the steel, instead of a granular or crystalline structure being shown the metal appears to have a flaky or fibrous structure, with what resembles slag between. In some respects the structure resembles that of ordinary wrought iron.

This appearance evidently is not affected, as might be expected, by the carbon content, where the steel has a high chromium content. Several experimenters have endeavoured to follow the composition of the structure by immersing the sample in weak acids so as to dissolve out the iron carbide, and then subject it to suitable polishing, prior to comparing with the original structure.

Düsseldorf Foundry Congress

Brief information is given of the International Foundry Congress, which is being held in Düsseldorf at the time of going to press. Reference is made to the Foundry Trades' Exhibition and to some of the works visits.

SPECIAL arrangements were made for members of the Institute of British Foundrymen to visit Düsseldorf, enabling them to take part in the World Foundry Congress now being held in that town. These arrangements permit of a seven-day period in Germany, and also give members the opportunity of attending the principal meetings of the Iron and Steel Institute.

The sixth Foundry Trades' Exhibition is taking place at Düsseldorf, in the Exhibition Hall on the Rhine (main entrance in the Ehrenhof), from September 17 to 27, and is sponsored by the Institute for German Industrial Propaganda (Berlin), in conjunction with the Chief Technical Committee for the Foundry Industry in Düsseldorf, and the Foundry Industrial Organisation. This combines all the members of the foundry trades—producers of castings, foundry machinery manufacturers, and makers of other foundry equipment. The Exhibition is divided into six separate and self-contained departments.

The International Foundry Congress is sitting from September 17 to 22. The main meetings terminate on Sunday, September 20, but arrangements have been made for the members of the Institute of British Foundrymen to leave Düsseldorf on the following Tuesday evening, thus giving them the opportunity of attending the meetings of the Iron and Steel Institute, visiting the Foundry Exhibition, or of personal sightseeing.

The party of members of the I.B.F. left London at 8-30 p.m. on September 14, and travelled via Harwich and the Hook, arriving at Düsseldorf at 11-34 a.m. the following day. On Wednesday, September 16, various industrial plants were visited, including the Deutsche Eisenwerke, Abt. Hüttenbetrieb, Meiderich, a foundry for rolls, ingot moulds, and engineering foundry for large machine parts; the Eisenwerk Wanheim, another engineering foundry, and with large workshops for machining, swaging shop and iron construction; and the vast Krupp works at Essen.

Thursday, September 17, saw the formal opening of the Congress and Exhibition, and on Friday morning various papers were presented and discussed as far as time permitted; the subjects ranged from moulding and casting technique to the metallurgy of iron, steel, and malleable castings, and included papers dealing with non-ferrous castings. On Friday afternoon more industrial plants were visited, these including the Yale and Towne Manufacturing Co., of Velbert, possessing large grey iron, malleable cast iron, and non-ferrous foundries, and the biggest lock-making plant on the Continent; the big grey iron and malleable cast-iron foundries of Aug. Engels, also at Velbert; the agricultural machinery plant of the International Harvester Co., Neuss; the foundry for both large and small Diesel motors of Humboldt-Deutz-Motoren A.G., Köln-Deutz; the Deutsche Eisenwerke, Abt. Schalker Verein, Gelsenkirchen, consisting of blast-furnace plant, foundry for compressed air-pipes, drain-pipes of cast iron, radiators and engineering foundry; and the Gutehoffnungshütte at Oberhausen, where this company were making a special show of the coal, iron, and engineering industry, including the descent of the Oberhausen mine and a film-illustrated lecture in the mine.

Further papers will be presented on Saturday morning, and in the afternoon members of the Institute of British Foundrymen are scheduled to carry out a visit of inspection to the Kaiser Wilhelm Institute for Iron Research at Düsseldorf. Papers will also be presented on Sunday morning, leaving the afternoon free.

The Foundry Exhibition is to be visited on Monday, September 21, but Tuesday morning will be kept free, as the party leave for England at 5-45 p.m. the same afternoon. Many members, however, will take the opportunity to attend the meetings of the Iron and Steel Institute in Düsseldorf on those two days.

A pre-Conference tour of Germany was arranged, and certain extensions are available. The latter includes a motor coach tour of Germany, travelling in two parties, which leave Düsseldorf on September 22 and 23 respectively. The route lies through Cologne, Dillenburg, Assmannshausen, Mannheim, Stuttgart, Augsburg, Munich, Nuremburg, Dresden, and Berlin.

Congress Papers

The papers that were scheduled for presentation included the following:—"Cast Iron and Its Present Position as Constructing Material" (Prof. Thum, Darmstadt); "Foundry Technique as an Introduction for Designing Engineers" (Prof. Kessner, Karlsruhe); "Modern Statistical Foundry Management" (Dr. Herbert Antoine, Berlin); "What Foundry Practice May Expect from Moulding Machines" (Prof. Dipl.-Ing. U. Lohse, Jena); "Influence of the Pressure Degree of Moulding Materials on Its Properties" (presented on behalf of the Czecho-Slovakian Foundry Association by Prof. Dr. Mont. Pisek and Ing. Homann, Brünn); "Contribution to the Estimation of Binding Agents in Moulding Sand" (Dr.-Ing. Schneider, Clausthal); "Contribution to the Standardisation of Testing Moulding Sands" (Mr. Fr. Boussard, Liege); "New Methods for Testing the Fineness of Grain of Moulding Sand" (C. Gierdziejewski and W. Gorycki, Warsaw, presented on behalf of the foundry division of the Technical Association of Poland); and "Testing of Oil Cores" (Prof. Dr.-Ing. Nipper, Aachen).

Among the prospective papers were a number dealing with the metallurgy of cast iron, malleable cast-iron, and steel. These included: "The Structure of Cast Iron" (Mr. J. G. Pearce, Birmingham, presented on behalf of the Institute of British Foundrymen); "Influence of Wall Thickness on the Mechanical Properties of Cast Iron" (Dr.-Ing. Jungbluth, Essen); "Impact Strength of Cast Iron" (Prof. Dr.-Ing. Piwowarsky, Aachen); "Metallurgical Principles of Manufacture of Foundry Pig Iron by a New Melting Process, considering especially the Desulphuration Process" (Prof. Dr.-Ing. Paschke, Clausthal).

Lock Manufacturing

One of the most interesting of the many industrial plants visited, or scheduled for a visit, was that of the Yale and Towne Manufacturing Co., at Velbert. Nearly all the company's export business is now handled from the German plant, with the exception of products for Great Britain and British Colonies, which is handled from Willenhall. The Velbert works have a total floor area of 50,000 square metres, and the principal products are locks of all kinds, lock furniture, door-closers, and chain blocks. This is probably one of the most modern iron foundries for this class of goods in Germany. The birthplace of the Yale industry was at Newport, U.S.A., where, about 1840, Linus Yale, senior, began the manufacture of "pin-tumbler" locks of decided mechanical excellence. Linus Yale, junior, continued his father's business, and became the leading lock expert of his day. He formed a partnership with Henry B. Towne to develop the business, and the Yale and Towne Manufacturing Co. became a corporate concern in 1883. The trade name of "Yale" was adopted as a trade mark, and does not mean a type of lock. It is not the name of any article, but an abbreviation of the company's corporate name, and used to indicate products made by that company.

The original products were Yale bank locks, cylinder locks, and Post Office lock boxes, and to these were added new lines from time to time, until the line now includes practically all types of lock mechanisms, in addition to

Grinding department of Yale & Towne's lock works.

material-handling equipment, such as chain blocks, electric hoists, and both hand and electric industrial trucks.

In the German works there are over 2,000 machines of all types in use. Many of the highly specialised automatic machines have been designed by the company's engineers, together with intricate dies and tools for performing combined operations. From the large material stores sheet steel, brass, etc., is passed to the press shops, where it is blanked, pierced, bent or drawn into the various individual shapes to meet the requirements of the numerous lock designs. Rod material is worked on special automatics and so pass to the machining and finishing shops. Grinding and polishing is handled in an up-to-date polishing shop. There is also modern electroplating equipment and conveyer type japanning and drying ovens.

Nearly all material throughout the works, and specially in the packing and assembling rooms, is on skid platforms. Material transportation within the works is accomplished by the use of electric and hand trucks. A staff of research men and engineers make up what the company call their "Methods Room," where technical problems are tackled, not only for the improvement of products, but also to improve manufacturing technique.

In 1928 the company bought the German business of Boge and Kasten, of Solingen, and combined it with the

One of the assembling shops in the lock works of Yale & Towne.

Yale business at Velbert. The Boge and Kasten trade mark "BKS" was so well known in Germany, especially in regard to door-closers, that the Yale and Towne Co. decided to continue its use. The mark "BKS" as used in Germany thus also represents products made by the Yale and Towne Manufacturing Co.

The chairman of this year's International Foundry Congress is Mr. W. Bannenberg, who is works' manager of the Yale and Towne Manufacturing Co.

Foundry Trades' Exhibition

The sponsors of the sixth Foundry Trades' Exhibition have laid themselves out, after systematic collaboration and every evidence of German thoroughness, to combine all members of the foundry trades into a comprehensive review of the whole foundry industry and to make this practical review of benefit to foundrymen throughout the world, making this a scientific representation of basic conceptions and explaining these with example. It forms a review on a scale never previously attained in Germany, and of a completeness never before known. The industry was sending its employees, buyers, technicians, workshop officials, etc., to the Exhibition.

The Institute of British Foundrymen made it possible for members to visit the Exhibition, attend meetings, and inspect industrial plant, in addition to social functions and personal sightseeing at very moderate charges and in a well-organised routine.

The previous Foundry Trades' Exhibition was held in 1929.

Iron & Steel Institute Meeting

(*Continued from page* 130).

and Mr. G. R. Bolsover. The authors consider that this subject has not received the recognition in Britain which it deserves, and have presented tests on a selection of steels made specially to demonstrate the difference in physical properties between relatively coarse and fine grain on the same cast of steel. Eighteen types of steel are used, in which the only variable within practical limits is the grain size. Although the main objective of this paper is to place facts based on an extended experience before those interested, views are expressed on the fundamental theory underlying the process of manufacturing steel of controlled grain size. It is suggested that inherent grain size is a function of the ultimate degree of deoxidation during steel manufacture.

The industrial application of developments within a particular technical field presents problems in related fields, which result in a constant increase in the number of problems with which the technical expert must deal. Thus, the rolling mill experts find themselves in that section of the operating field in which the metallurgist passes the cast metal on for the first step of its working. The problems arising are discussed in a paper by Albert Nöll, who describes the varied requirements taken into consideration when determining the construction of the modern rolling mill. The author discusses the development of the small-section and rod rolling mills; strip rolling mills; rolling mills for wide strip; the improvement of the working of old sheet rolling mills; the production of very wide and heavy sheet; and tube-making.

A notable recent development in the processing of thin wide flat steel products has been the evolution of cold-rolling from a mere sizing and polishing operation, carried out as sparingly as possible, into an economic means of effecting a substantial reduction in thickness of such products. Thus, heavy cold-rolling is assuming an increasing degree of importance as an economic means of improving metallurgical, superficial, and dimensional qualities. This change has been largely brought about through the virtual rediscovery of the potentialities of the backed-up mill concurrently with the development of improved roll-neck bearings. The greater use of heavy cold-rolling operations on mills of this type has drawn attention to the rolls employed, and this problem is discussed in a paper by Messrs. Geo. A. V. Russell and S. S. Smith. The authors record the results of fairly extended experience with the rolls of a modern installation of backed-up mills of the four-high type for the processing of brass and copper sheet and strip.

Progress in Steels for the Petroleum Industry

By L. SANDERSON

The author summarises the principal advances made during the last year or two, especially those of direct importance to the petroleum industry.

IT is all too readily assumed that as a result of the existing industrial depression research into and progress in steels have ceased. That this is not so the present article will demonstrate. It is an attempt to summarise the principal advances made during the last year or so, especially those of direct importance to the petroleum industry.

Perhaps the most interesting development has been in connection with the pipe for pipe-lines. For some considerable time it has been the aim of manufacturers to produce a better type of pipe for a lower cost. Partly, this has been due to pressure along these lines from the petroleum industry itself, partly as an attempt to get ahead of rivals in the pipe industry. It will be appreciated that when roughly 50% of the installation cost of a pipe-line is represented by the cost of the steel, the subject is of no mean importance.

At the outset, an attempt was made to reduce the cost of pipe by reducing the initial weight of the steel itself. This was achieved by lessening the thickness of the walls of the regulation lap-welded tube, and guarding this less robust pipe with great care against the possibility of corrosion from outside. Next, it was found that greater strength combined with lighter pipe could be achieved by fabrication of the pipe from high-tensile steel sheet or plate by means of fusion welding. As a rule, lap-welded steels have but low tensile strength, whereas with fusion-welding it is possible to use steels with a tensile as high as 28 tons per sq. in. In this way, the weight of the pipe was reduced by approximately 50% (*i.e.*, by reducing the wall-thickness and employing fusion-welding). Naturally, the saving represented was considerable.

A final step was the discovery of a method of making seamless pipe of large diameter from an even better quality of steel, with the result that a tensile strength of approximately 32 tons per sq. in. is now attainable.

The advances in the type of steel employed were primarily caused by the increasing need of more and more resistant and strong pipe. Similarly, connections for casing or lining the deeper-driven wells had to be strong. The type of steel now being used contains approximately 0·30% carbon (sometimes higher), with manganese approximately 1·40 or higher, but never more than 1·50. Where corrosion is probable, a small percentage of copper is sometimes added to increase the resistance to attack. No heat-treatment is usually given to the steel in advance of use, but experiments on these lines with a view to increasing the mechanical strength of the material was in progress, while efforts are also being made to produce a steel for pipe lines which will give a tensile strength as high as 45 tons per sq. in. Such a steel will probably contain alloys. In any event, the steel now being produced is far and away superior to ordinary carbon steel, and the facility with which it can be fuse-welded has in many instances enabled the joints to be welded, instead of its being essential to provide screw joints, the threading for which seriously reduced the wall thickness of the pipe.

In the previous paragraph, reference has been made to the need of a strong but inexpensive steel for casings for deep oil and gas wells. In this field the low alloy steels containing chromium, silicon, and manganese are rapidly achieving supremacy owing to their possession of exceptionally advantageous characteristics, such as good ductility and high mechanical strength. The composition of this range of steels is usually 0·5% chromium, 0·8% silicon, and 1·3% manganese. The carbon varies from 0·3 to 0·4%, as may be required for specific purposes, since this steel is used for other purposes, in addition to casing tube.

Steels of this type have a good yield-point, are rugged, readily machinable, ductile, homogeneous, and possess a high elastic limit. Their properties are, in short, far and away superior to those of the carbon constructional steels, while they can be rolled, pierced, and drawn with very little additional difficulty or cost.

Turning to another development, this is the production of a semi-mild nickel steel for chains, the steel being cast into individual links, which are then united in a continuous chain by the casting of intermediate links, 2-and-2, in special moulds. A heat-treatment is afterwards given to the chain thus made, consisting of an annealing treatment to restore the grain, then water-hardening and tempering.

Another interesting advance is the production and utilisation of nickel alloy steel castings for core-cutter heads, used in drilling oil wells. These cutter heads, made from heat-treated steel castings, have a composition that includes 1·25% nickel and 0·60% of chromium, though this composition varies a little according to the manufacturer's ideas. The cutting edges are faced with " stellite," which is not a steel, but a type of cutting alloy. In some of these cutter heads high-pressure slurry is pumped between the inner and outer edges of the core drill, and washes the cutting edges of the core-drill head. The advantages of castings made from the steel in question are that they have improved toughness, as can be seen by examining their ductility and impact figures. They have a refined grain, and will respond readily to proper heat-treatment. This heat-treatment has the advantage that it increases the mechanical strength of the material, while at the same time, owing to the depth of the treatment, this increased strength does not vary with the thickness of the section. In addition, such castings resist shock and have a high yield-point.

Not only is a steel of this character valuable for cast core-cutter heads, but it is also suitable for Diesel engine connecting rods, sluice valves, kiln tyres, gearing, excavator racks and pinions, tractor parts, and so forth.

Another alloy steel valuable in the cast form is the nickel-chrome steel, the composition of which is approximately 2·05% nickel, 0·80% chromium, and 0·35% carbon, specially suitable for high-temperature fittings in power plants and oil refineries.

Alloy steels are, in fact, continually extending their service to the petroleum industry, and within the last twelve months another has been announced primarily for tubes in high-pressure boilers, super-heaters, and cracking stills. This, at a much lower price than the normal rust- and corrosion-resisting " stainless " steels, gives creep strengths that can be compared with these more expensive high-temperature steels, and in addition to the purposes outlined, it can be used for bolts, tube-ends, and similar products where corrosion is not a serious factor.

A most important development is the improvement in the manufacture of stainless steel castings. Until recent months, the great difficulty with stainless steel castings has always been the poor quality of the finish. Pitting and

roughness seemed inevitable. The steel foundries have now, however, overcome yet one more obstacle, and stainless steel castings are now obtainable with a very fine smooth finish, free from roughness. All those small fittings and parts not previously obtainable in this material are now to be had at a much lower price and in much quicker delivery time.

The legitimate stainless steels (*i.e.*, those of the nickel-chromium type) have made such progress that there is scarcely an industry in the world into which they have not penetrated, and this is true of the petroleum industry, where a dozen uses in oil-refining and corrosion-resisting can be found for them. The main outlines of their progress over the past few years have been too closely followed to need elaboration here. It will be sufficient, therefore, to run lightly over the most recent changes.

Then there is the invention of free-machining stainless steels with a selenium content. Stainless steels were always difficult to machine, which limited their application; but steel-makers overcame this trouble by raising the sulphur content, which softened the steel. At the same time, however, this increase in sulphur had the grave drawback that it lowered at the same time the mechanical strength of the steel. By adding selenium and leaving the sulphur content normal, the same free machining properties are obtained, but what is more, the mechanical strength is not so greatly lowered, and the corrosion-resistance is better than with the sulphur-bearing steels.

A further important advance is the elaboration of a stainless steel that can be satisfactorily welded without a further normalising treatment being required after the welding operation. This greatly enlarges the scope of stainless steels, since some parts of the plant are too large to be normalised after welding, while where it was necessary to weld *in situ*, as in fabricating large vessels, normalising was impossible.

In the development of the specifically heat-resisting steels, much progress has been made. A chrome-tungsten steel is one of the last to be put on the market. This has been evolved particularly for parts where the lowest possible creep at high temperatures, combined with as great a retention of strength as possible, are desired. Another new or newish steel has a high chromium content, but contains in addition such elements as silicon or aluminium, or, in certain instances, 20% or over of nickel. This is for the purpose of offering maximum resistance to oxidation at high temperatures.

It will be seen that research and progress have by no means been discontinued in the steel industry, and when it is realised that the advances detailed cover only those of interest to one specific industry, some idea will be obtained of how eagerly and closely the technical problems of the world are being studied by steel manufacturers.

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Institute of Metals

(*Continued from page* 128)

fracture, on the other hand, increases continually with temperature until a sudden decrease takes place at the melting point. Comparative curves follow the same course, the maximum being replaced, in the case of the more plastic alloys, by a fictitious flat, due to the passage of the test-piece between the supports. This flat ends, almost invariably, about 35° C. below the solidus.

Comparison Between Static and Dynamic Bending.—If capacity of deformation be defined by the bend in static bending and by the angle of fracture in dynamic bending, it is observed that the curves follow the same course and have a maximum, which is very much less marked for the angle α. The capacity for deformation by shock is, therefore, very much less, and sometimes the maximum disappears. The positions of the maxima on the temperature scale do not agree on static and dynamic tests, being higher on the latter; this is connected with the influence of recrystallisation after deformation, which is greater on slow deformation.

It appears that the absence of a maximum on the dynamic curves (or a very small maximum) indicates an alloy which is not practically forgeable, while even a narrow flat on the static curve indicates an alloy which can be forged at slow speeds or rolled. The curve of variation of work absorbed on shock ρ is in general the same as that of the angle of fracture α, and is unaffected by the maximum noted on that of the static load of fracture. In certain cases a maximum angle of fracture occurs without the occurrence of a maximum of work absorbed, at any rate in the same temperature range (*e.g.*, aluminium + 5% magnesium).

Comparison of the Results Obtained on the Different Dynamic Tests.—This comparison only holds for alloys which are neither too brittle (aluminium + 12–15% magnesium) or too ductile (pure aluminium). The curves representing capacity for deformation (those of the angle of fracture α, the elongation A % or the reduction in area Σ %) follow the same course without the maxima always occurring at the same temperature, those of tensile tests being generally lower (magnesium + 6% aluminium; aluminium + 5% magnesium or 6% copper); this is doubtless due to the influence of deformation by compression during bending.

The work absorbed in bending ρ, or in tension T, undergoes the same kind of variation, but T has sometimes a maximum at low temperatures (100°–200° C.)—*e.g.*, in magnesium + 3% aluminium and aluminium + 5% magnesium. Under the experimental condition employed, the work absorbed on shock, ρ, gives the more sensitive and more economic evaluation; although the work absorbed in tensile shock gives, for the very ductile materials (unalloyed aluminium and magnesium), a value in accord with that of fracture in the region of deformability (which is not the case in bending); this is not of great practical interest, since in any case the thermal region for forging is clearly indicated by the constant value of the flats on the curves.

To sum up, static or dynamic bend tests appear to be the most suitable, convenient, and rapid for studying the forgeability of light and ultra-light alloys; where the metals are difficult to forge these tests make possible a determination of the best temperature range in which to carry out the work.

Comparison Between the Different Alloys Investigated.—From the results of these tests, it would appear that magnesium alloys can be extruded up to about 15% of copper and about 9% of aluminium, and can with care be forged up to about 15% of copper and 7–8% of aluminium. As for the aluminium alloys, that containing 12% copper should be able to be extruded and forged with care; while for those containing magnesium, the limit of forgeability must lie between 5 and 10% magnesium for metals of the purity employed.

Pulverised Fuel Equipment in the Malleable Foundry Industry

The Metallurgical plant recently installed in a large malleable cast iron foundry is discussed with regard to furnace firing.

FIRING by means of pulverised fuel gives considerable advantages, and has wide application in metallurgical processes. An outstanding application is that at the works of Messrs. Leys Malleable Castings Co., Ltd., where considerable extensions have been made and pulverised fuel firing is employed in the melting furnaces and annealing ovens in the foundries, and also for auxiliary firing in the boiler-house in the works power station. The boilers are normally heated by the waste gases from the furnaces, the pulverised fuel supply being used when sufficient waste heat is not available.

At these works the metallurgical plant consists of six melting furnaces, twenty-four annealing ovens, and four reheating furnaces. The generating plant consisted originally of a 300-kw. turbo-generator; two 1,350 kw. turbo-alternators have since been added. There are two complete pulverised fuel handling and storage plants, both of which were supplied by Messrs. Fraser and Chalmers' Engineering Works. The latest of these plants, installed in connection with the recent extensions, supplies two melting furnaces, eight annealing ovens, two reheating furnaces, and one of the waste heat boilers when auxiliary firing is required.

The general arrangement of this plant is shown in Fig. 2, from which it will be seen that there are three main sections—raw coal storage, drying and pulverising, and pulverised fuel distribution, each with its associated handling and other equipment. The whole plant is electrically operated.

Raw Coal Storage

Raw coal, consisting of 1½ in. × ¾ in. washed smalls, containing about 15% moisture, is unloaded from the trucks into a 10-ton receiving hopper, fitted with a grid to prevent the entrance of foreign matter. A 20-in. apron feeder leads from the hopper discharge to the foot of a bucket elevator between two 200-ton silos (Fig. 1), to the top of which the coal is lifted at the rate of 15 tons an hour; here a three-way valve enables the coal to be discharged into either silo or into a chute leading to a 20-ton raw coal bunker. Coal is withdrawn at the bottom through three openings with rack-and-pinion gates, beneath which run two screw feeders (one for each silo) leading to the base of the elevator. Thus the raw coal bunker can be filled either directly from the receiving hopper or from the storage silos as required.

Drying and Pulverising

In order to prevent any tendency of the pulverised product to pack in storage, and also to enable the grinding mill to give its maximum output with minimum current consumption, it is necessary to dry the raw coal. It is therefore extracted from the bunker by means of a variable speed reciprocating screw feeder (a duplicate feeder is installed as a standby) and fed at the rate of 2 tons an hour to a dryer of the Ruggles-Coles type. This dryer reduces the moisture content from 15 per cent. to 2 per cent., and is fed with hot gases generated in a small hand-fired furnace burning about 45 lb. of coal per ton of coal dried.

The fines carried away by the exhaust gases from the dryer are recovered by passing them to the top of a precipitator, which is capable of dealing with 1,800 cub. ft. of gas per minute. The dust precipitated is fed through a dust-pipe and rotary air-lock to join the dry coal at the discharge end of the dryer, while the cleaned gases pass to atmosphere through a stack-pipe.

The coal from the dryer is ready for pulverising, and is passed through an Avery automatic weighing machine to a surge hopper, from which an adjustable reciprocating screw-feeder delivers it to an air-swept ball mill of the Hardinge

Fig. 1.—Raw coal silos, 50 ft. × 16½ ft. internal diameter, with chain and bucket elevator.

type, 6 ft. diameter and 36 in. long. The mill capacity is 2 tons of coal an hour, and it reduces the coal from 1½ in. × ¾ in. to a fineness such that 85 per cent. will pass through 200 B.S.S. mesh; it runs at 26 r.p.m., and (with the screw-feeder) is geared to a countershaft driven through vee-belts by a 60 h.p. 725-r.p.m. slip-ring motor. The coal-laden air is extracted by a fan and delivered to the top of a cyclone separator, where the coal is settled out and passed through a rotary air-lock and a two-way chute into one of two 15-ton storage bins.

Pulverised Fuel Distribution

The pulverised fuel is distributed on the Fraser and Chalmer's system, in which primary air is blown through pipe-lines, the coal being sucked in at suitable points. Three fuel lines, each containing an injector, are provided, the longest being 440 ft. long; two lines lead to 20-ton melting furnaces, and one to the waste-heat boiler, enabling the latter to be provided with an auxiliary supply of

fuel when the temperature of the flue gases is not high enough to generate the steam required.

The primary air supply is provided by two fans, each of which has a capacity of 3,400 cub. ft. per min. at 21 in. W.G.T.H. ; these fans discharge into a header feeding the injectors through suitable control valves. Eight annealing ovens and two reheating furnaces are fed from a further circulating main, through which air saturated with coal dust is passed by one of two blower fans, each having a capacity of 1,750 cub. ft. per min. at 25 in. W.G.T.H. ; the annealing line can be vented to the bag filter, so that the whole system can be emptied of coal when necessary.

The pulverised coal for the fuel lines is fed through flexible pipes from three 8-in. feed screws at the bottom of each storage bin, each feed screw being driven through gear-box and roller chain by a 1½-h.p. variable speed d.c. motor, 500/1,500 r.p.m. ; the capacity of each screw ranges from 1,200 lb. to 3,600 lb. per hour, depending on the speed ; by substituting chain drives of different ratio, the maximum capacity can be reduced to 1,700 lb. per hour. Four flexible connections are provided and are interchangeable, allowing any feed screw to discharge into any injector or circulating main as required. As each feed screw operates independently, this is a very flexible arrangement, giving a wide range of feeds and alternative feed methods.

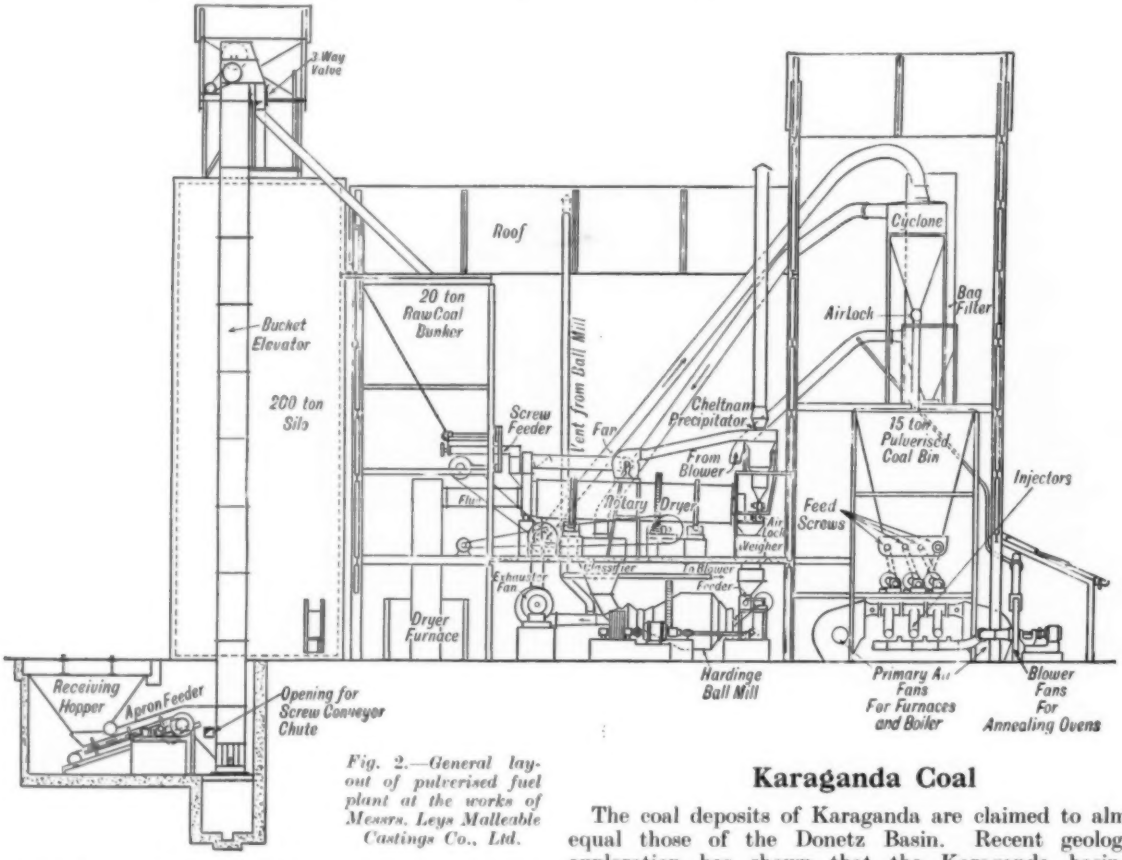


Fig. 2.—General lay-out of pulverised fuel plant at the works of Messrs. Leys Malleable Castings Co., Ltd.

Electrical Equipment

The constant speed drives are equipped with protected type a.c. motors running at 720, 950, or 1,450 r.p.m., and supplied at 400 volts, three-phase, 50 cycles, from the works supply. The Hardinge mill is driven by a slip-ring motor, equipped with an air-break rotor starting panel. With this exception, squirrel-cage motors are employed throughout ; standard machines are used on the screw feeders under the silos and the rotary air-locks, and high torque motors for the fans, Roots' blower, dryer plant, and raw coal feeder and elevator. Motors below 10 h.p. are equipped with direct-to-line contactor starters, and the larger machines with stator resistance starters. In all cases the starters are push-button operated, and additional push buttons are provided for remote control from convenient points.

Variable speed drives for the pulverised fuel feed screws are provided by totally enclosed shunt-wound motors, fed at 220 volts d.c. from the works' supply. Each motor is equipped with an air-break timing starter, provided with separately mounted push-buttons interlocked with a 31-point shunt regulator. Interlocking features are provided in other parts of the control gear where necessary. The electrical plant and equipment has been manufactured and installed by the General Electric Co., Ltd.

We are indebted to Messrs. Leys Malleable Castings Co., Ltd., for permission to publish this description, with the accompanying illustrations.

Karaganda Coal

The coal deposits of Karaganda are claimed to almost equal those of the Donetz Basin. Recent geological exploration has shown that the Karaganda basin in Kazakhstan contains about 60,000 million tons of coal. The existence of coal in Karaganda has long been known but the extent of the deposits has only just been revealed, In 1918 it was thought that the deposits were only 100 million tons.

In recent years the output of coal in Karaganda has been mounting rapidly. In 1930 Karaganda supplied the Union with 12,000 tons of coal and last year with 2,350,000 tons. The estimated output for this year is 3,300,000 tons.

New Steelworks at Rotherham

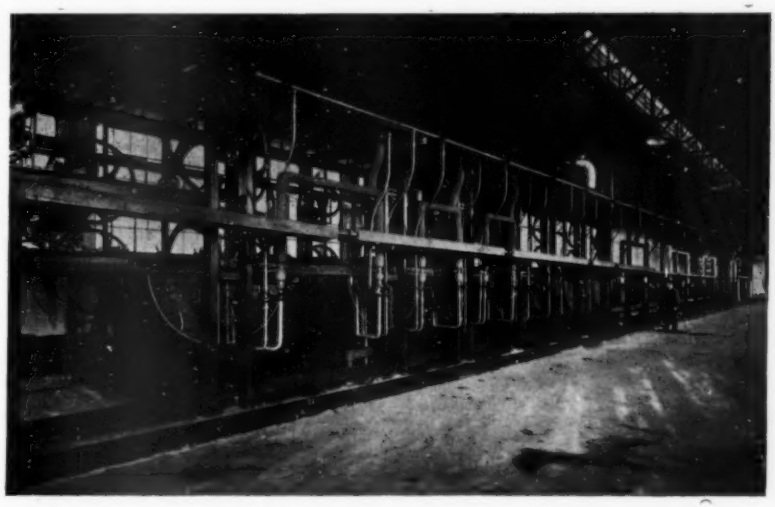
A new steelworks is being erected at Rotherham for the production of cold-rolled strip. Sheffield and district steelmakers in recent times have added considerably to their facilities for manufacture, but the demand is so insistent that all the mills are fully occupied and there is a surplus of orders. Skilled men have been engaged and production will be started as soon as the plant has been delivered, probably in October, The style of the works will be Eastwood Rolling Mills,

Electroplating

Considerable expansion has taken place in the electroplating industry during recent years, largely due to improved methods of control, and in this article many aspects of the process are discussed.

ELECTROPLATING being so widely applied to-day, it is particularly appropriate that the Chemical Section of the British Association, at its annual meeting, held at Blackpool, has devoted much attention to the part taken by chemists in developing this industry. Six papers on the subject were presented at the meeting. In introducing the subject, Mr. D. J. Macnaughtan mentioned that it was just 100 years ago that Professor Daniell, of King's College, London, described the cell that still bears his name, which was the first primary cell to provide a steady current suitable for electroplating under industrial conditions. The work of Professor Faraday, who established the laws that govern the relationship between the quantity of current and the amount of metal deposited, and also originated the terms now universally used in the industry, was also discussed.

The early development of the electroplating industry took place in Birmingham, chiefly due to the Elkingtons, who were receptive of new ideas and ready to back them with faith and money. The first practical dynamo actually used for silver-plating was also produced in this town. Faraday lived long enough to become acquainted with the successful efforts of Wilde, of Manchester, to greatly improve the efficiency of the dynamo. It was, however, in the year of Faraday's death, in 1867, that Wild's greatest achievement, a dynamo then regarded as a colossus, was acquired by a son of one of the Elkingtons for the first plant for copper refining. This was the beginning of the electro-refining industries, the direct offspring of electroplating, which by the continuous efforts of chemists, was to grow to enormous dimensions and vastly increase the world's supply of silver, gold, and other rare metals, and provide for industrial purposes a number of important metals in a state of hitherto unattainable purity.



Typical example of an automatic nickel-plant, by W. Cannings and Co., Ltd.

The heaviest electroplated coating is probably that of lead, which has certain uses for materials to be used in contact with corrosive chemicals; the thickness may be of the order of three-thousandths of an inch. Deposits about one-third of this thickness—*i.e.*, one-thousandth of an inch in the case of nickel and silver—provide lustrous attractive coatings which will stand a considerable amount of wear. About one-half this thickness in the case of zinc and somewhat less in that of cadmium ensures a relatively long life in the prevention of rusting of steel. In the case of tin, two ten-thousandths secures excellent protection of the basis metal for use in contact with many foodstuffs. Untarnishable coatings of chromium satisfactory for some years of outdoor exposure are provided by a thickness of the order of two hundred-thousandths of an inch (when applied on an initial coating of nickel one-thousandth of an inch in thickness).

For most applications of coatings of the precious metals—gold, platinum, palladium, and rhodium—the order of thickness of the deposits generally used is only a few millionths of an inch. This thickness is only a fraction of the wave-length of visible light, and is beyond the limits of resolution by the microscope. It is interesting to note that if stripped off the basis metal it would be possible to see through these precious metal films, the light received by the eye being of a delicate tint of green, or possibly blue or even red. Yet in spite of their extreme tenuity, these films are sufficient to ensure the maintenance, over long periods, of the attractive appearance of gold on all kinds of works of art.

Deliberately formed oxide films are now much used for providing a protective coating, also capable of decorative treatment, on aluminium, and this has become of importance in the electroplating industry owing to the fact that electrolytic methods of forming them have proved highly successful. These electrolytically formed (anodised) films are immensely thicker than the air-formed film on chromium, and are in fact usually about twice the thickness of the normal chromium deposit—*i.e.*, about four hundred-thousandths of an inch.

The foregoing shows that over a range of thickness, from a few millionths of an inch to coatings a thousand times thicker, electroplating allows the utilisation of about fourteen metals for the treatment of an amazing variety of products.

Control in Electro-deposition Processes

Mr. A. W. Hothersall describes the work of the chemist in providing improved methods of control which have enabled the industry to meet the demands for more rapid production and for coating of better quality. In this paper the electrodeposition is described as consisting of two main stages: the preparation of the polished article, freed from all traces of grease, dirt, or oxide, ready to receive a coating; then its immersion in the plating solution, with a suitable current passed through the solution. The quality of the coating and the cost of the process are determined by the control of these two stages of cleaning and deposition.

In decorative plating, a very high degree of adhesion between the coating and the underlying metal is not generally regarded as essential, but certain engineering applications of electrodeposition depend for their success on the coating remaining adherent under heavy stresses. Investigation of adhesion has revealed interesting facts, and has led to remarkable practical results. For the strongest adhesion, not only must all grease and dirt be removed, but also the surface of basis metal must be

dissolved away. Mechanical treatments applied before plating to give the metal the required shape and surface finish—for example, rolling, machining, polishing, etc., weaken the surface layer and often render it specially susceptible to embrittlement by hydrogen evolved during plating. Removal of a thin surface layer of the metal by etching has been found greatly to increase the difficulty of detaching the deposit, so much so that the coating may be regarded as forming an integral part of the article. The modern electro-deposition process thus enables working parts of machines which are locally worn to be restored to size by building-up, and also renders possible other engineering applications of electro-deposited metals in which the coating is subject to high stresses.

Electro-deposition

Turning to the electro-deposition process, the general tendency has been towards a simplification of the complicated baths used in the early days of the industry. With the development of more precise methods of control, it became possible to determine the function of the individual constituents of the solutions and to improve and simplify the formulæ on rational lines. By these means the rapidity of the process was greatly increased, so that whereas a nickel coating of good quality required some 3–4 hours for deposition 30 years ago, the same thickness of metal can now be formed in 30–40 minutes, or even less. In the developments which have taken place, attention has been chiefly focussed on nickel deposition, since coatings of nickel form the foundation of the majority of chromium coatings plated to-day.

The most important method of control applied by the chemist to plating solutions is the precise measurement of effective acidity, which is expressed by the symbol *p*H. With the introduction of the *p*H method of testing, many of the vagaries in the behaviour of nickelplating solutions disappeared and more consistent results were obtained. Furthermore, the investigation of the causes of defects in nickel deposits became profitable. For example, the tendency of nickelplating to crack and peel is due to the stress in the deposit, which varies with conditions of deposition, such as acidity and temperature, and is increased by certain impurities. The stress may be minimised by a proper control of these conditions and by the use of suitably pure solutions.

Other causes of defects, such as pits and the tendency to unequal distribution of deposit, have been remedied or reduced as a result of laboratory investigations, and it is now generally established that electro-deposited coatings of high protective value *can* be obtained commercially and that the thickness of the coating provides in most cases a reliable index of its quality. Very recently, a simple and accurate chemical test has been developed whereby the thickness of coatings of nickel, copper, bronze, zinc, and cadmium can be determined at any desired point on an article in the course of two or three minutes. Details of this test will shortly be made available to the public; I mention it now to show that the way is paved for a standardisation of coating in terms of their quality.

Electro-deposited Coatings as Corrosion Preventives

The function of the electro-deposit is mainly twofold—viz., decorative and protective. Other valuable properties may be imparted to the surface as a result of electro-deposition, states Dr. S. Wernick, of which one of the most important, as for example, in the case of nickel and chromium plating, is added hardness. The corrosion of metals is a matter which affects us closely, since the loss entailed as a result of corrosion constitutes one of the most serious drains on the world's resources, and during the present century electro-deposited or electroplated coatings have been used to an increasing extent to combat this loss. In the protection of iron and steel, zinc and cadmium plating in particular have been developed and utilised on a rapidly increasing scale commercially.

The relative advantages of zinc and cadmium plating industrially have been fully explored, and a field of usefulness has resulted for each type of protective in consequence. Thus, it has been proved as a result of a number of researches that cadmium is somewhat superior to zinc as a protective for ferrous material under relatively mild conditions—*e.g.*, interiors and rural atmospheres,—while zinc-plating is better when protection is required in exposed or very wet conditions.

The production of electro-deposits of zinc and cadmium of good quality is dependent on the use of an electrolyte of balanced composition, facilitating the maintenance of uniform conditions. The electrolyte almost invariably in use in the case of cadmium is an alkali double cyanide, while both acid sulphate and cyanide solutions are used in zinc plating. In the case of the cyanide solutions, the conditions which require to be controlled are the concentration of the constituents of the electrolyte (metal, free cyanide, and caustic alkali), the current density, the temperature of the solution, and the anode-cathode area ratio. Equal rates of solution of the anode and deposition at the cathode are also obviously necessary to maintain the metal content of the electrolyte. The optimum operating conditions have been determined, and any marked diversion from these results in an appreciable change in the structure of the deposit, which in turn affects the corrosion-resisting properties of the coating. The most desirable type of deposit is one which has a very fine structure, since this type of deposit provides the maximum degree of protection to the basis metal.

Dr. Wernick gave considerable attention to anodic oxidation as a means of protection. This is a very important electrochemical application, which cannot perhaps be strictly termed electro-deposition, since this is not so much a depositing process as the transformation of the metal surface into an oxide.

Non-tarnishable Finishes

Non-tarnishable finishes are discussed by Mr. E. A. Ollard, who states they have been developed largely as a result of modern conditions. Unfortunately, the materials which were easiest to apply as coatings by electro-deposition or other means all tarnish comparatively easy, even though they may be used for protecting steel against corrosion of a more severe nature. Thus, while nickel, copper, zinc, and tin have been used for protection of steel for many years, and nickel also as a protection on brass and copper, none of these metals give finishes which will remain bright indefinitely without the application of some kind of mechanical polishing.

Chromium was one of the first metals to be investigated with a view to the production of a non-tarnishable finish, but it was some years before the technical difficulties attending its deposition were overcome. The chemistry of chromium is somewhat involved, and it is by no means an easy metal to reduce electrolytically, especially when it is desired to obtain thin bright adherent coatings. However, a careful research into the chemical and electrochemical properties of solutions of its compounds revealed the fact that it was possible to obtain suitable coatings of chromium from chromic acid solutions which contain a small and carefully controlled quantity of sulphate. Originally the chromium was applied directly to the base metal for which protection was desired, but while this plating gave good results on nickel silver, on steel, brass, or copper it was not found entirely satisfactory, and in fact on steel the chromium plating gave very little protection. It was subsequently found that the success of a chromium deposit depends rather more upon a coating of nickel than upon itself, for unless the nickel deposit is thoroughly adherent and non-porous the final finish will be unsatisfactory, and the chromium will not fulfill the purpose for which it is required.

If sterling silver or even high-class silver plate is to be protected against tarnish a precious metal must be used, and for this purpose rhodium may be considered the most

satisfactory, although in some cases either palladium or platinum might be used. Palladium is somewhat cheaper than rhodium, but is less resistant to wear, so that in general a thicker coating must be used, and the price difference becomes less apparent. Of the three, rhodium has become by far the most popular, owing to the fact that it is extremely resistant to corrosion, and also has a hard surface which is not easily scratched. It is even comparatively unattacked by aqua-regia, which will dissolve practically every other known metal.

Non-tarnishable finishes, such as chromium and rhodium, being both hard and chemically inert, may be used technically for purposes where it is desired that an article shall be protected against corrosion, erosion, or both. In this connection we may mention the printing industry, and the facing of printing plates, etc. Chromium has been greatly used for this purpose, since it not only resists the attack by the inks that are used, but also the wear which would otherwise soon spoil a block having a copper or nickel surface.

Advances in Electroplating

In almost every country, during recent years, the tendency has been to take the control out of the hands of the plater and carry out the whole plating process in specially designed automatic units, states Mr. C. F. J. Francis-Carter, where pre-treatment and cleaning processes, together with the actual plating, occur in their proper sequence. The design of such units has been made effective by the co-operation of the chemical engineer, who was able, by the application of his principles and a knowledge of corrosive-resisting materials of construction, to overcome the many new and difficult problems.

The first automatic plating plant was built and installed in England in 1920, for depositing nickel and silver on lamp reflectors. This was followed by a similar one a few years later, but it was not until 1929 that the first of the modern type plants was built, for depositing the nickel underlay for subsequent chromium plating. This was followed by two more in the same year, and there are now, in all, 27 plants at work in this country. They cover the deposition of pure metals, such as cadmium, chromium, copper, nickel, silver, tin and zinc, of alloys such as bronze, brass, and zinc-cadmium, and, where no intermediate polishing is required, cater for dual deposits in their proper sequence, such as nickel and silver, or copper and nickel, or include special treatments after the depositing process, such as oxidising or chemical colouring. In fact, there is no deposit which could not be deposited in an automatic plant if required.

In the course of his paper, Mr. Francis-Carter referred to the modern degreasing process, which, although not a plating process, now almost invariably precedes, at one stage or another, the actual plating. Using the non-inflammable solvent trichlorethylene in suitable but easily operated plants, metal parts covered with oil, grease or polishing compositions may be rendered clean and grease-free in a few minutes. This process has superseded older methods of dipping in inflammable spirit, such as petrol or swabbing with boiling caustic alkalies, and is yet another of the chemist's and chemical engineer's contributions to industrial electroplating.

The Future of Electro-deposition

In discussing the future of electroplating, Dr. H. J. T. Ellingham predicts further development, since more precise control of the plating process is likely to lead to further improvements in the quality and reliability of electro-deposited coatings and an expansion of the range and scale of their application.

Moreover, the number of metals deposited in electro-plating practice will no doubt be increased. Of about thirty metals known to be capable of electro-deposition from aqueous solutions, fourteen may be said to come within the range of present-day plating practice. Of about forty other metals—which probably cannot be electro-deposited from aqueous solutions—many are actually produced commercially by electrolysis of their molten salts, but this generally yields the metal also in the molten state. Deposits of these metals suitable for plating purposes may be obtainable, however, from solutions of their salts in solvents other than water, and electrolysis of such non-aqueous solutions for the production of coatings of metals such as aluminium, magnesium, beryllium, and tantalum—as well as of tungsten and molybdenum, which may be obtainable also from aqueous solutions—has been the subject of several recent investigations.

Coatings of tungsten, molybdenum, manganese, iridium, aluminium, and beryllium, are among those which would seem likely to find useful applications when satisfactory processes for their deposition have been worked out. According to a recent report, the electro-deposition of manganese in the form of bright, coherent coatings from aqueous sulphate solutions of carefully controlled *p*H value is now being undertaken for the commercial extraction of the metal from its ores.

Apart from the development of these new types of electro-deposited coating, the range of application of deposits already used in present-day practice is also likely to be greatly extended. The introduction of new methods and processes in other industries continually opens up new possibilities. Thus, the fact that in some modern tin-plate mills the steel sheet is finally cold-rolled in the form of a continuous strip renders it easily amenable to electrolytic pickling treatment, since it can be passed continuously through a pickling bath. Moreover, it can then be passed similarly through a plating bath, thus rendering it possible to apply the tin coating by electro-deposition instead of, as hitherto, by dipping in molten tin.

In considering the future of the electro-deposition of metals it will be realised that each new development will have to meet competition from other types of coating and other types of surface treatment, which will be developing simultaneously, and one of the chief lessons to be learned from past experience is that the continued progress of electro-plating practice is greatly dependent on the maintenance of close co-operation between the plating shop and the research laboratory. Nobody can foretell what kind of new advances in pure chemistry will give the key to the next important developments in electroplating, and it is most important therefore that the practical man shall keep in touch with progress in various branches of the science upon which his industry depends. It is in the nature of things that the most striking advances in science and in scientific industries are those which are the least predictable. Indeed, anything which is predictable is already on the way to becoming commonplace. It is safe to say, therefore, that the really startling future developments in electroplating will not be those to which reference has been made, but others which are so novel that they are hardly conceivable in the basis of our present knowledge and experience.

World Shipping

During the last 12 months ending in June, there was a decrease in world steam tonnage of 708,340, an increase of 985,908 in the motor tonnage, and a decrease in the tonnage of sailing vessels and non-propelled craft of 99,897, making a net increase of 177,671 tons. Between June, 1934, and June, 1935, there was a net decrease of 690,640 tons. The countries showing notable increases for the last 12 months were Panama (292,491 tons), Italy (213,753 tons), Japan (130,040 tons), Soviet Russia (104,126 tons), Greece (89,685 tons), and Norway (86,513 tons). The largest decreases amongst the principal maritime countries were the United States (293,962 tons) and Great Britain and Ireland (114,950 tons).

Steam and motor tonnage has increased from 24,008,883 in 1901 to 64,004,885 this year, but Great Britain's percentage has dropped from 50.2 in 1901, to 26·8 in 1936. Slightly less than 50% of the tonnage of the world's merchant marine now depends entirely upon coal; in 1914 the percentage was nearly 89.

Business Notes and News

Silver Jubilee Memorial Cottages

At the recent inspection of the new coke-oven and by-product recovery plant, which has been installed at the works of The Workington Iron and Steel Co., and which is described elsewhere in this issue, an interesting ceremony took place in the official opening of a number of cottage homes. These cottages are the outcome of a decision by the United Steel Companies, Ltd., to present to the employees of the Company a sum of money for the creation of a permanent memorial to mark the Silver Jubilee of his late Majesty King George V. The Works Council at Workington decided that cottage homes for retired employees would be most fitting to commemorate the Jubilee Year, and in this decision they were supported by Works Councils at other Branches of the Company.

At Workington eight cottages have been erected, and ample ground area is available to extend the scheme at a future date. The design of the cottages, which is uniform throughout the Combine, is very attractive and incorporates a compact layout with a high degree of comfort. The cottages are thoroughly labour saving and very suitable for occupation by elderly people. The management of these cottages is vested in a Committee composed of representatives of the workpeople and of the Company.

The Foundry Technical Group

The first session of the British Foundry School has now closed, and the students have formed an association called "The Foundry Technical Group." The aim of the Association is to maintain social and professional contacts within the Group and with the School. By way of reunion, an annual function will be held in Birmingham.

The following officers have been elected for the session :—President, J. G. Pearce, Esq., M.Sc., M.I.E.E. ; Chairman, J. R. Booth, Esq. ; Hon. Treasurer, J. Bamford, Esq., B.Sc. (Eng.) ; Hon. General Secretary, R. V. Dowle, Esq. ; Hon. Report Secretary, H. Walton, Esq., B.Sc. (Eng.) ; Hon. Recorder, C. A. J. Timms, Esq. ; and Sessional Representative, R. O. Patterson, Esq.

The following students of the Foundry School have been awarded the Diploma following the examinations of the Session 1935–36 :—Messrs. L. Berry, F. P. Birch, J.R. Booth, R. V. Dowle, J. W. C. Johnson, J. L. King, H. C. Newby, R. O. Patterson (Distinction in Foundry Planning and Casting Studies, Ferrous and Non-Ferrous), G. H. Rhodes, S. A. Shaat (Distinction in Foundry Technology), J. McI. Shand, H. Walton, B.Sc. (Distinction in Foundry Management), and M. A. Wardle.

Non-Magnetic Ship

The Admiralty has decided to build a non-magnetic ship for the purpose of compiling accurate magnetic data at sea. The vessel is to be known as the Royal Research Ship, *Research*. The plans for the vessel have been prepared by the Admiralty, and the scientific world has been awaiting the news that the order had been placed.

The vessel is intended to replace the non-magnetic ship *Carnegie*, which was destroyed by an explosion in 1929. Its destruction brought to an end the magnetic survey of the oceans, which had been carried on for 25 years by the Carnegie Institution of Washington. The results obtained were placed freely and promptly by the Carnegie Institution at the disposal of the British and other Governments for use in the construction of world magnetic charts.

Stantons Increase Blast-furnace Capacity

The Stanton Ironworks Co., Ltd., are at the present time increasing their blast-furnace capacity by making it possible to blow an additional furnace at their Stanton Works and an additional furnace at their Holwell Works. When these additions are completed they will be able to work at the same time five furnaces at Stanton (instead of four) and four furnaces at Holwell (instead of three). These in addition, of course, to the two furnaces recently erected at Wellingborough. Opportunity is also being taken of installing a mechanical pig-casting machine at Holwell.

Effects of Better Trade

It is customary to refer to the rise of industrial shares as an indication of increased prosperity, this method however, does not give convincing evidence of recovery in those areas which have been particularly hard hit as a result of depressed trade. It is more convincing that public authorities are now feeling the cumulative effects of improved trade and their financial position is much healthier than for some years. The experience of the Tees Conservancy Commission and the Tees Water Trade Board are typical of the majority of similar authorities engaged in the provision of Public services closely connected with industry.

It is noteworthy that the revenue of the Conservancy Commission during the first nine months of the authority's year has increased by £10,300, equal to 11%, while in the same period 132,000 tons more shipping has made use of the river. Industrial consumption of water supplied by the Tees Valley Water Board during the past 29 weeks averages 6,000,000 gallons a week more than in the corresponding period of last year, and it is highly probable that the £135,000 paid to the Corporations of Middlesbrough, Stockton and Thornaby for 1935, will be improved upon when the current year's operations are completed.

Steel Imports

According to the Board of Trade, imports of iron and stee into this country, during August, were 92% more than in the same month last year, most of the increase being in crude metal. The steel exports of this country last month were 15% less than a year ago, although more railway material was shipped. The output of pig iron, steel ingots and casting last month exceeded by over 200,000 tons that of August, 1935.

"Queen Mary" Sister Ship

It has been announced that the keel of the sister ship to the *Queen Mary*, "No. 552," is to be laid down in November next. The Cunard-White Star Line state that the new ship will be of the same approximate dimensions as the *Queen Mary*, but it is not yet possible to say what her tonnage will be. The ship will probably be launched during 1938 and delivered early in 1940.

German Copper Mining in Jugo-Slavia

As Germany is the main buyer of Jugo-Slavian blister copper, it is not surprising to hear a report (from Belgrade) that a German mining company is in course of formation with the object of acquiring a copper mining concession in Jugo-Slavia. The negotiations regarding the concession are well in progress and completion is expected at or before the end of September.

Capital will be subscribed by certain prominent German metal manufacturers, with several of the leading German banks collaborating. The present annual production of Jugo-Slavian copper is 45,000 tons, from the French-owned Mines de Bor. Preparations are in hand for the erection of an electrolytic refinery at the mines, thus aiming at securing the strategic copper supplies of the Little Entente. The object of the German company in this endeavour to commence its own copper mining in that country is evident. It is not possible to envisage whether this move will be, or become, of international significance.

Davy Bros. Acquire Roll Firm

The Directors of Davy Brothers, Ltd., Sheffield, announce that the Company has acquired the business of British Chilled Roll and Engineering Co., Ltd., Empire Works, Haverton Hill, Middlesbrough.

The Board of Directors of British Chilled Roll and Engineering Co., Ltd., has been reconstituted and now comprises Mr. E. J. Fox, Chairman, Mr. S. B. Toy and Mr. D. F. Campbell. Mr. S. V. Toy will act as Technical Director and Mr. H. B. Toy remains in a consultative capacity.

New Zealand's First Electric Train

New Zealand has placed an order in Great Britain for its first electric motor-coach trains. They are to be put into service on the New Zealand Railway's routes. They will be the first all-steel coaches ever used in that country. Each coach will seat 140 passengers.

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Grinding Machines.	The Churchill Machine Tool Co., Ltd., Manchester.
Capstan & Turret Lathes.	H. W. Ward & Co., Ltd., Birmingham.
Planers, Shapers and Slotters.	The Butler Machine Tool Co., Ltd., Halifax.
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Chinese	54	0	0
Crude	25	0	0

BRASS.

Solid Drawn Tubes	lb.	9¾d.
Brazed Tubes	„	11¾d.
Rods Drawn	„	9d.
Wire	„	8d.
*Extruded Brass Bars	„	4½d.

COPPER.

Standard Cash	£38	19	0
Electrolytic	43	5	0
Best Selected	42	15	0
Tough	42	5	0
Sheets	70	0	0
Wire Bars	43	15	0
Ingot Bars	43	15	0
Solid Drawn Tubes	lb.	10¾d.	
Brazed Tubes	„	10¾d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	3	1½
‡Ferro Tungsten	„	0	3	0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL 2–4% Carbon, scale 11/- per unit	ton	29	15	0
NOMINAL 4–6% Carbon, scale 7/- per unit	„	22	7	6
NOMINAL 6–8% Carbon, scale 7/- per unit	„	21	12	0
NOMINAL 8–10% Carbon, scale 7/- per unit	„	21	12	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	33	10	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	5	0
§Guar. max. 0·5% Carbon, scale 12/6 per unit	„	37	5	0
‡Manganese Metal 97–98% Mn.	lb.	0	1	2
‡Metallic Chromium	„	0	2	5
§Ferro-Vanadium 25–50%	„	0	12	8
§Spiegel, 18–20%	ton	7	10	0
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	9	0	0
45/50% basis 45%, scale 5/- per unit	„	12	5	0
70/80% basis 75%, scale 7/- per unit	„	17	6	6
90/95% basis 90%, scale 10/- per unit	„	28	17	6
§Silico Manganese 65/75% Mn., basis 65% Mn.	„	12	5	0
§Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	22	0	0
§Ferro-Molybdenum, Molyte	lb.	0	4	6
§Calcium Molybdate	„	0	4	2

FUELS.

Foundry Coke—				
S. Wales	—	1	10	0
Scotland	—	1	10	0
Durham		1	4	6
Furnace Coke—				
Scotland	—	1	5	0
S. Wales	—	1	5	0
Durham	—	1	1	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£60	10	0
*Commercial Ingots	45	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0 9
*Cored Bars	„	0	0 11

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	10	10	0
Best Bars	10	2	6
Common Bars	9	5	0
Lancashire—			
Crown Bars	9	12	6
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars	9	12	6
Marked Bars	12	0	0
Unmarked Bars from	7	5	0
Nut and Bolt Bars £8 10 0 to	9	0	0
Gas Strip	10	12	6
S. Yorks—			
Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	11¼d.
†Sheet to 10 W.G.	„	11¾d.
†Wire	„	1/0½
†Rods	„	10¾d.
†Tubes	„	1/2
†Castings	„	1/0½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£4	5	6
Foundry No. 1	4	1	6
„ No. 3	3	19	0
N.E. Coast—			
Hematite No. 1	4	5	6
Foundry No. 1	3	17	6
„ No. 3	3	15	0
„ No. 4	3	14	0
Silicon Iron		—	
Forge	3	14	0
Midlands—			
N. Staffs Forge No. 4	3	17	0
„ Foundry No. 3	4	0	0
Northants—			
Foundry No. 1	4	3	0
Forge No. 4	3	14	6
Foundry No. 3	4	0	0
Derbyshire Forge	3	17	0
„ Foundry No. 1	4	3	0
„ Foundry No. 3	4	0	0
West Coast Hematite	4	5	6
East „ „	4	5	6

SWEDISH CHARCOAL IRON AND STEEL.

Export pig-iron, maximum percentage of sulphur 0.015, of phosphorus 0.025.
Per English ton Kr. 113

Billets, single welded, over 0.45 Carbon.
Per metric ton Kr. 255-325
Per English ton £13 7 6/£17 0 0

Wire Rods, over 0.45 Carbon.
Per metric ton Kr. 305-355
Per English ton £16 0 0/£18 12 6

Rolled Martin iron, basis price.
Per metric ton Kr. 200-220
Per English ton £10 10 0/£11 10 0

Rolled charcoal iron, finished bars, basis price.
Per metric ton Kr. 290
Per English ton £15 4 0
f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£29	0	0
„ Braziery	26	0	0
„ Wire		—	
Brass	19	0	0
Gun Metal	28	0	0
Zinc	9	0	0
Aluminium Cuttings	74	0	0
Lead	13	10	0
Heavy Steel—			
S. Wales	3	5	0
Scotland	2	17	6
Cleveland	2	17	6
Cast Iron—			
Midlands	2	12	6
S. Wales	2	17	6
Cleveland	3	5	0
Steel Turnings—			
Cleveland	2	0	0
Midlands	2	0	0
Cast Iron Borings—			
Cleveland	1	7	6
Scotland	1	17	6

SPELTER.

G.O.B. Official		—	
Hard	£11	15	0
English	15	2	6
India	12	15	0
Re-melted	13	10	0

STEEL.

Ship, Bridge, and Tank Plates			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	8	10	0
„ „ (Marine) „		—	
„ „ (Land), N.E. Coast	8	10	0
„ „ (Marine) „	8	17	6
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	10	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £6 17 6 to	7	2	6
Medium Basic £6 12 6 and	7	0	0
Soft Basic	5	10	0
Hoops £9 10 0 to	9	15	0
Manchester Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to ⅛ in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ¼ in.	„	3d.
„ „ ¼ in. × ⅛ in.	„	1/-

TIN.

Standard Cash	£194	5	0
English	194	10	0
Australian	194	5	0
Eastern	195	5	0

Tin Plates I.C. 20 × 14 box 18/9

ZINC.

English Sheets	£24	10	0
Rods	25	10	0
Battery Plates		—	
Boiler Plates		—	

LEAD.

Soft Foreign	£16	12	6
English	18	15	0

*McKechnie Brothers, Ltd. Sept. 14. †C. Clifford & Son, Ltd., Sept. 14. ‡ Murex Limited, Sept.. 14.
Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.
§ Prices ex warehouse, Sept.. 14.